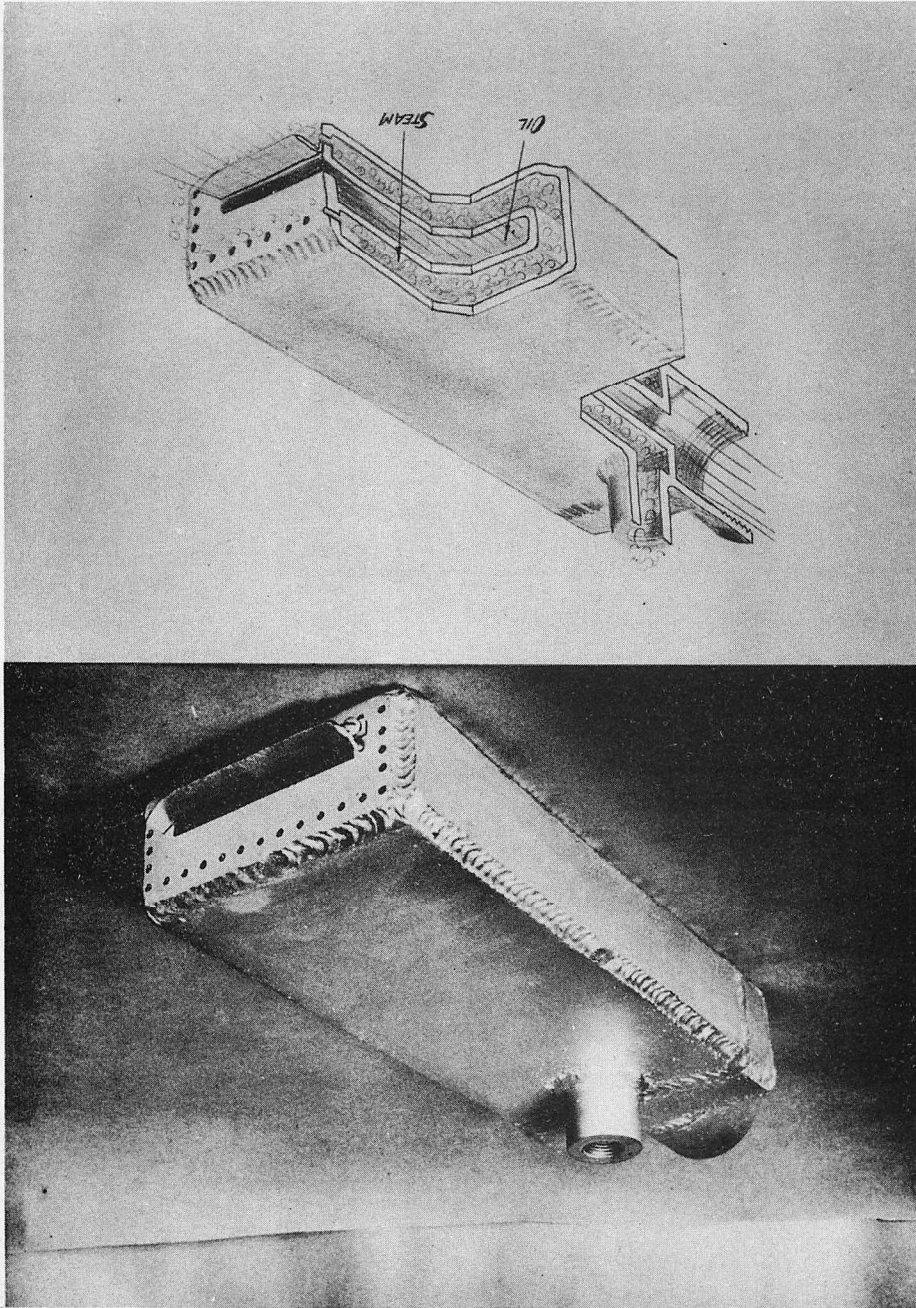


This was an experimental burner designed to disclose any advantage that might ensue from completely enclosing the oil stream with atomizing steam jets. The jets were uniformly spaced around the end of the burner and a small removable lip was provided at the oil outlet. In the interior of the burner the steam surrounded the oil passage.

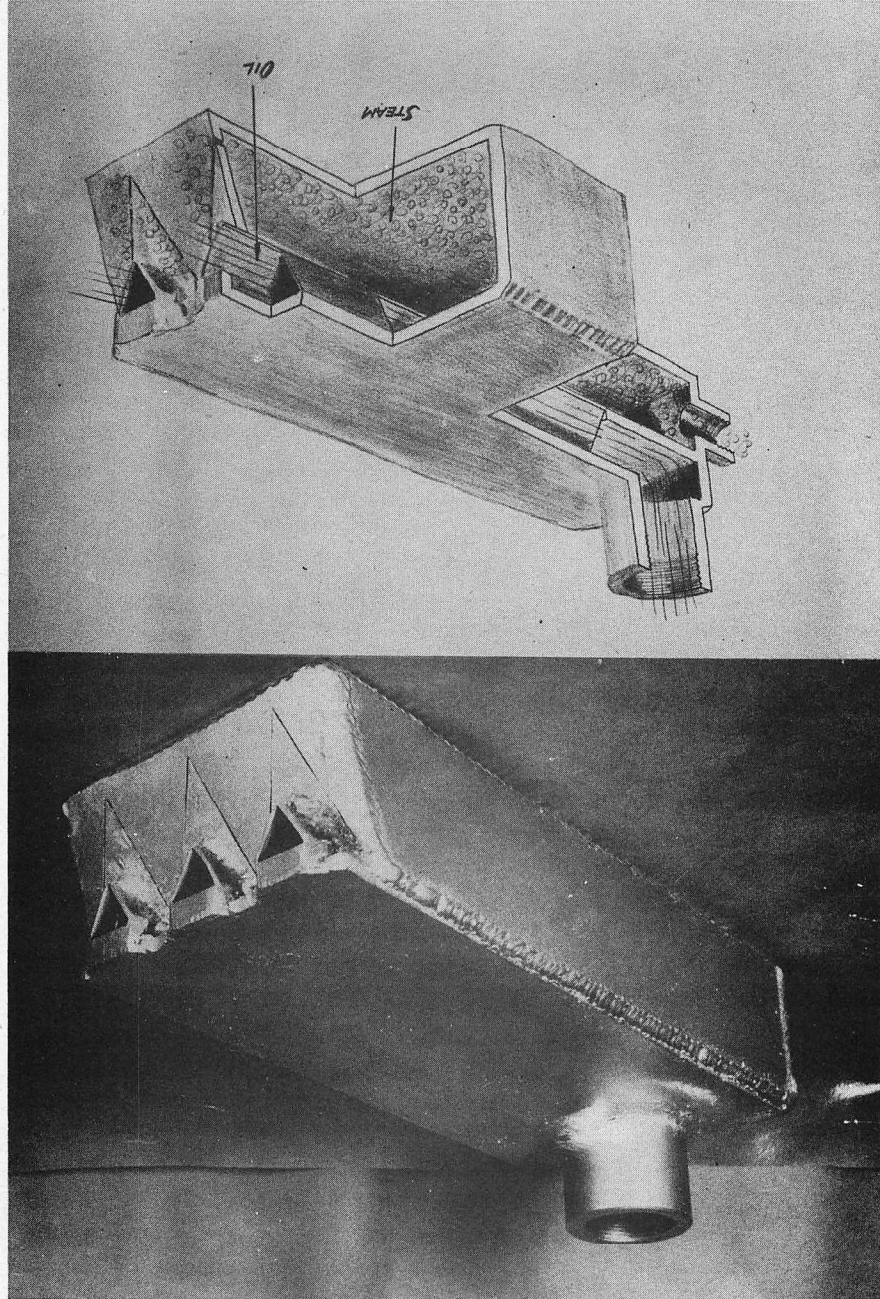
MULTIPLE JETS IN RECTANGLE BURNER

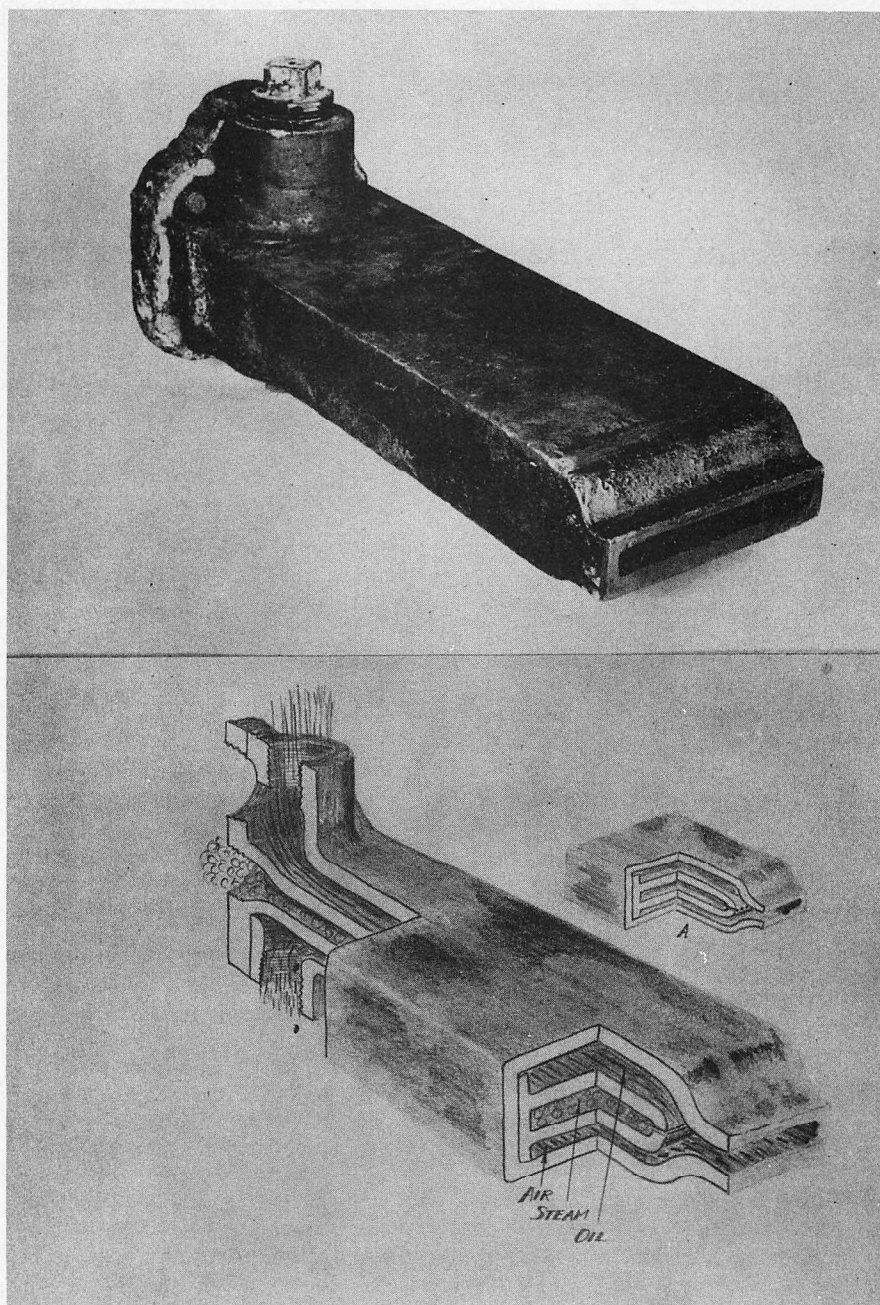


MULTIPLE VEE-JET BURNER

This was an experimental design burner. The oil entering the top connection divided inside the burner and passed through three separate triangular passages to the three separate and also triangular outlets over individual, Vee shaped steam jets. The oil passages were closed slightly at the top to form the outlet, but being inside the passage this lip did not serve to deflect the oil stream into the jets. Because of the method of providing the 1/64" thin slot for the Vee jet, the jet issued perpendicular to the sloping plate and not in line with the burner axis.

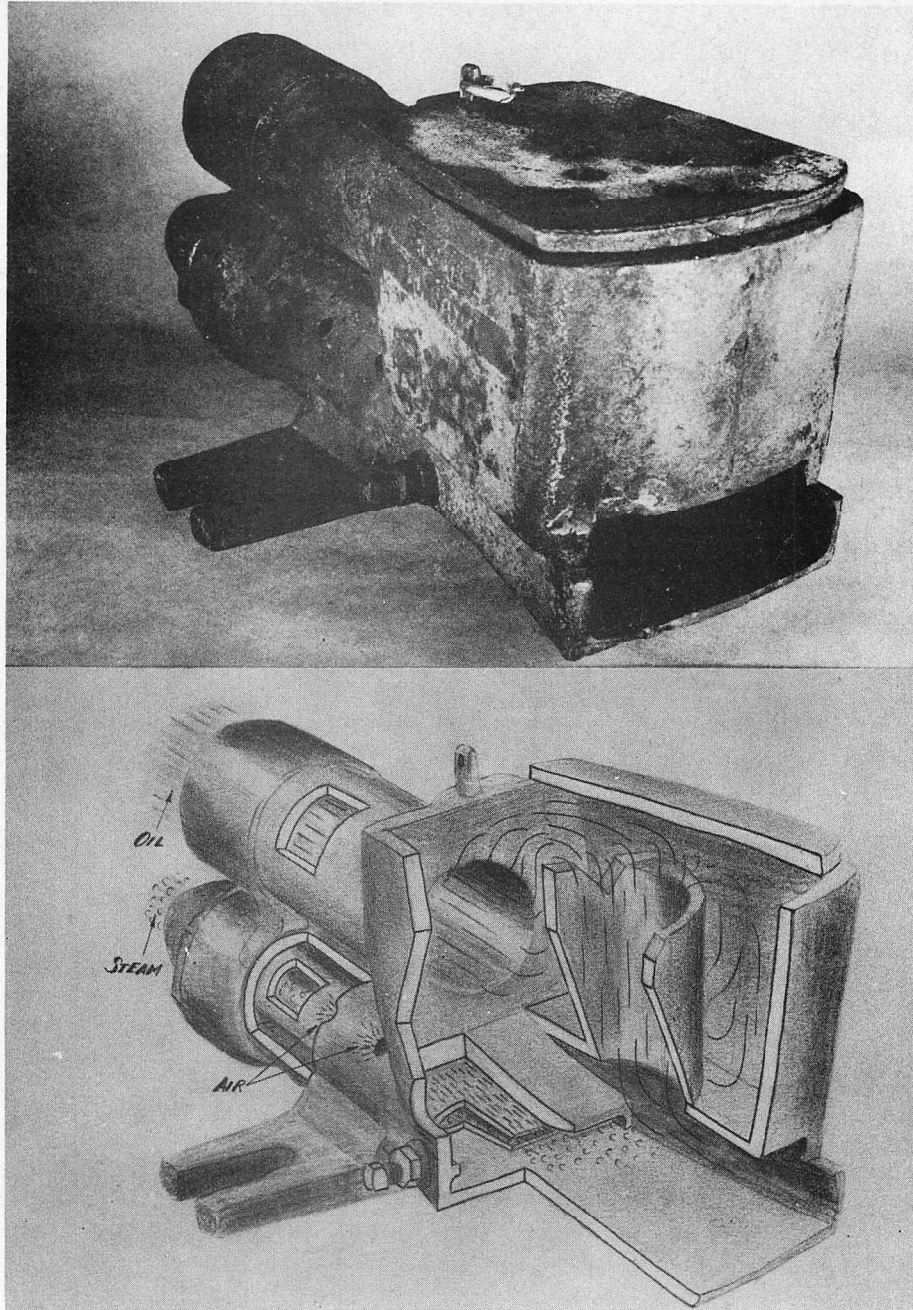
Photo No. 5-12





SHEEDY BURNER

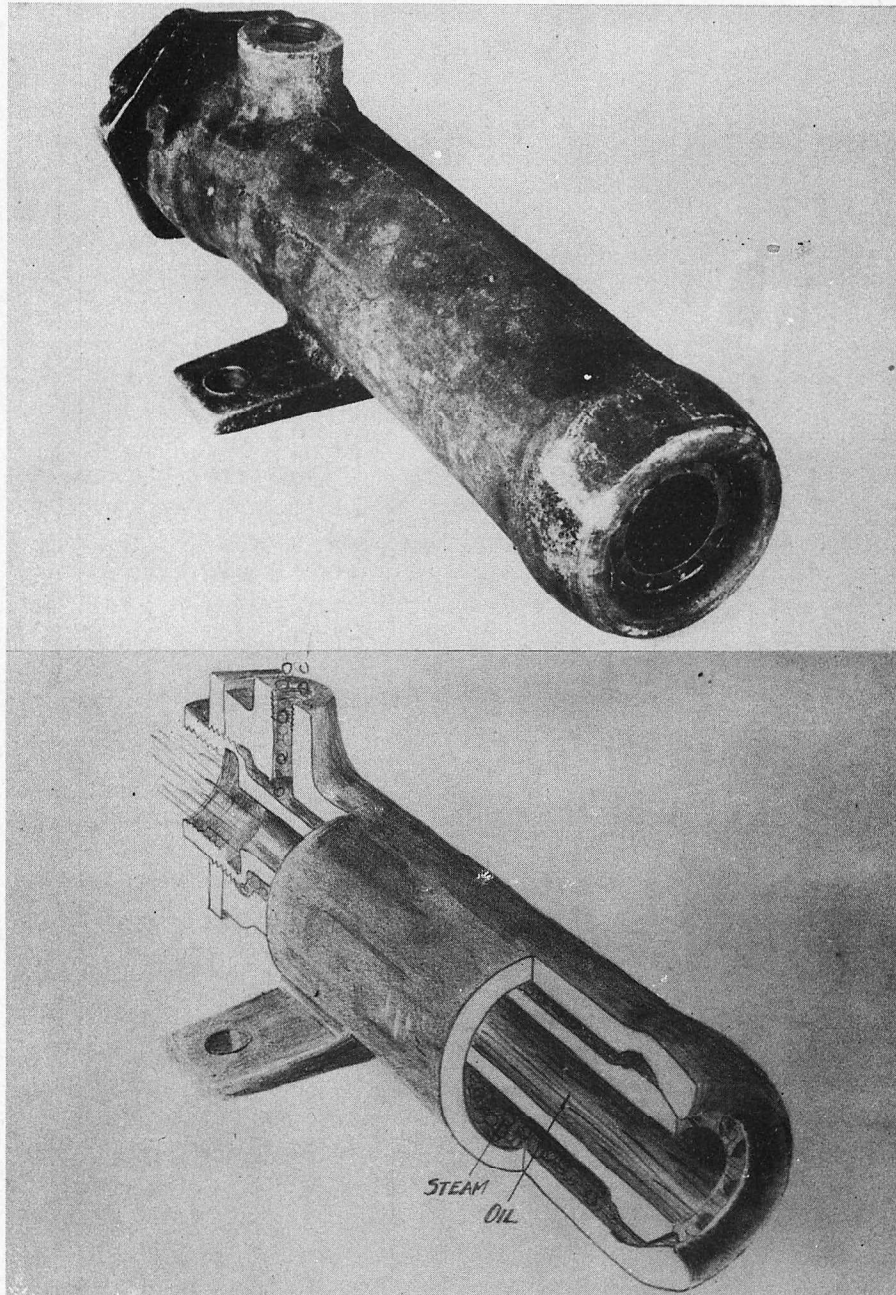
This burner was at one time quite extensively used on Pacific Lines locomotives. It was composed of two castings which when assembled, provided a central steam space above which was the oil passage and below which a passage for aspirated air was formed. The steam section terminated inside the outer housing where, in the standard burner, a steam slot was provided with jet directed out through burner outlet. In the modified design, 14, 3/32" diameter, taper reamed, expanding nozzles were provided instead of the plain steam slot. In trials, a valve was connected to air inlet by a short length of pipe to permit operation with or without aspirated air.



BRITTAİN BURNER

As may be noted, this burner was quite complicated. The steam issued from an inserted section, positioned by the external adjusting screws, in a flat jet. The location of the jet in an inner chamber, caused air to be inspired through the several small holes shown. The oil on entering the burner, passed through the tubular section into the reservoir or weir chamber, where, depending on the oil rate, it flowed onto the steam jet through the low Vee notch in the forward part of the weir column, that notch and the two higher ones toward the rear, or, over the whole upper edge of the column. The top of the weir chamber was loosely attached.

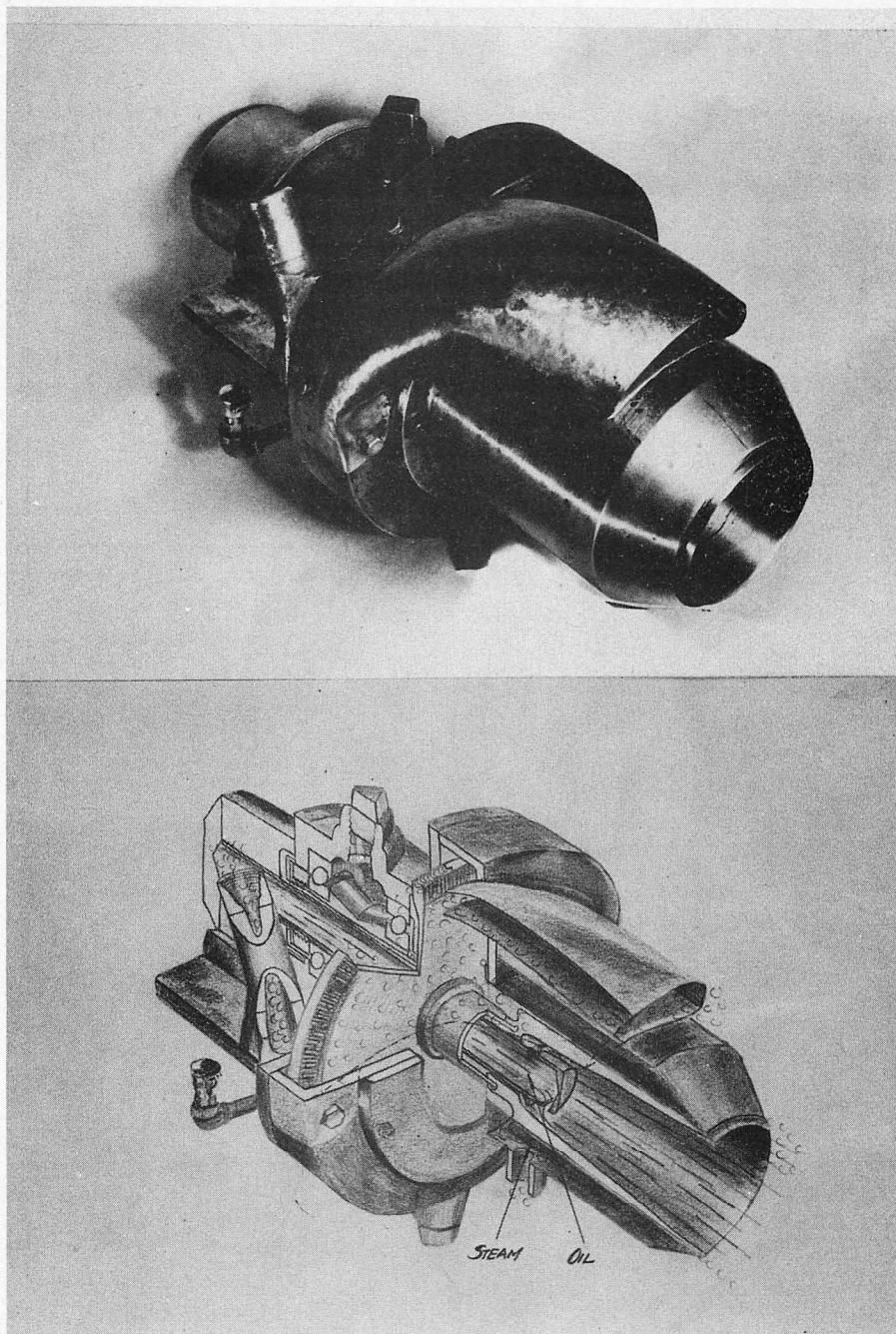
Photo No. 5-14



CLARK BURNER

This was the only tubular type burner known to be in service on Class I railroads. The burner consisted of two separate castings which, after assembly, were secured in position with the jam nut shown. Milled slots on the atomizing end of the inner casting formed the atomizing steam nozzles in the assembly, the open side of the slot being closed by the fit of the outer member. The slots were milled at an angle on the truncated conical end of inner piece, which caused the jets to cut across the edge of the oil stream, thereby imparting a rotation to the jet. The rounded end on the outside member appeared to be mainly to buttress the inner fit.

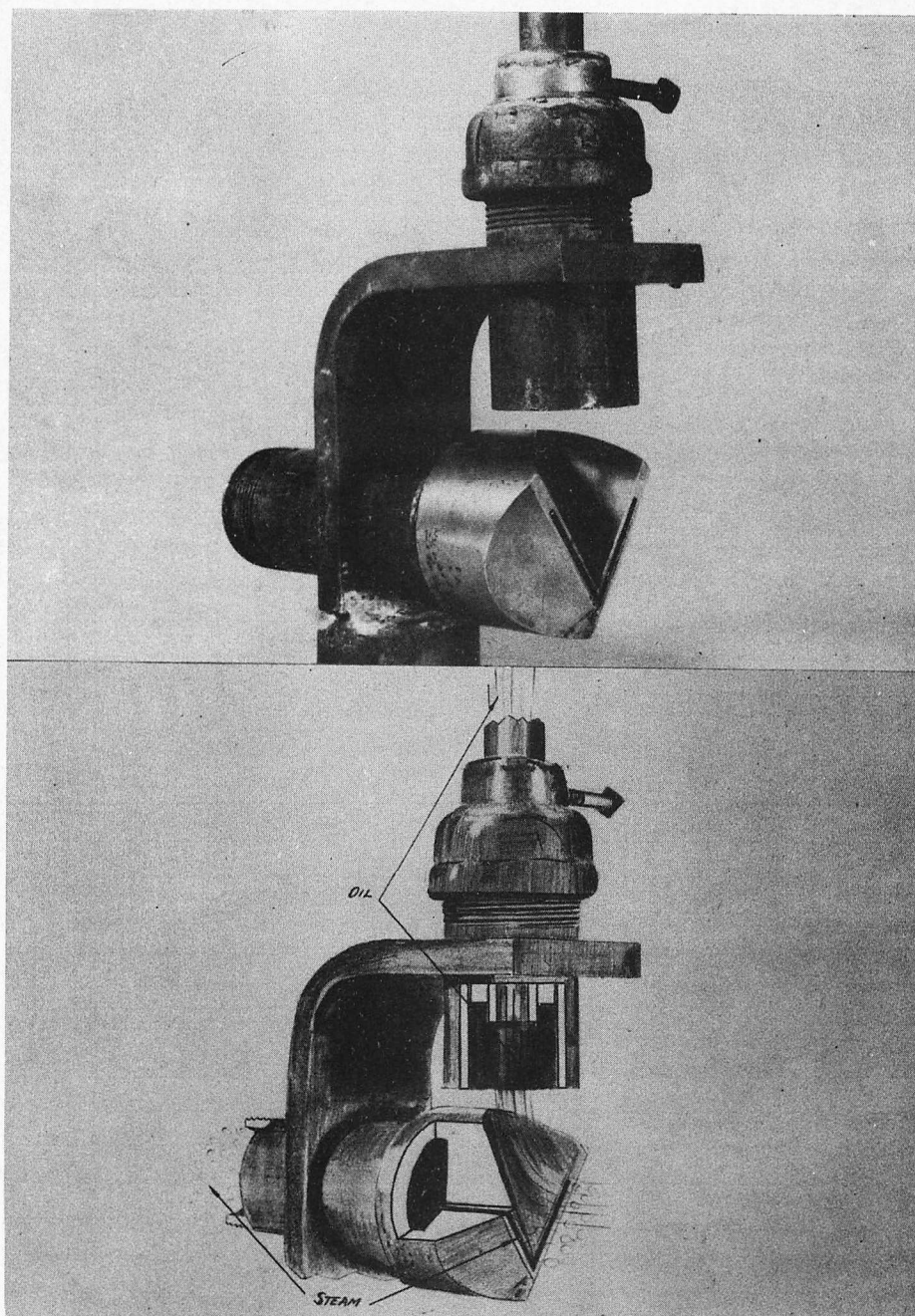
Photo No. 5-15



ALEXANDER ROTARY-CUP-TYPE BURNER

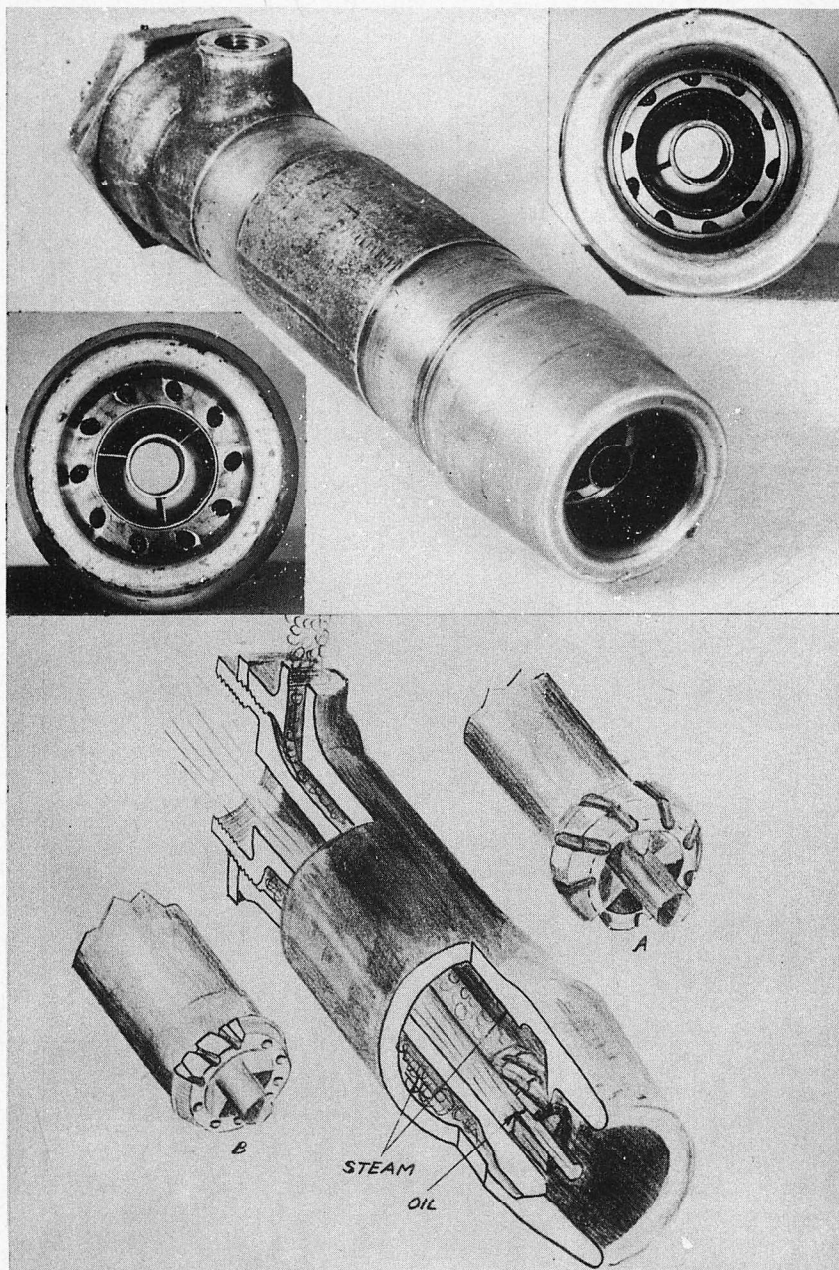
This burner was the well established rotary cup type burner but was specially designed to use steam for both motive power and atomization. The fuel oil entered burner at connection in rear cap and passed through center of burner in a stationary oil tube to outlet in rotating cup. Rotating cup was mounted on a hollow shaft driven by steam directed through nozzle at vaned turbine wheel, all being supported by two large, heavy duty ball bearing assemblies. Atomizing steam was connected to annular chamber in housing around cup and issued from thin annulus at end. For trials, exhaust from turbine was vented through "ram's horn" to burner port.

Photo No. 5-16



BATTELLE SLAG BLOWING TYPE BURNER

This experimental steam atomizing oil burner patterned from slag blowers used in the manufacture of rock wool was designed at Battelle. The oil dropped from the inner, 1/2" pipe above the V-blowhead into the trough of the V shaped steam jet. The high velocity steam sheared the falling oil, resulting in atomization. The steam left the burner parallel to the axis of the pipe which supplied the steam. The distance the oil fell was adjustable in the experimental design to permit attaining maximum atomization. The outer, 1-1/2" pipe in which the small oil pipe was held central by a collar, protected the falling oil from being blown away from the burner before reaching the steam jet.

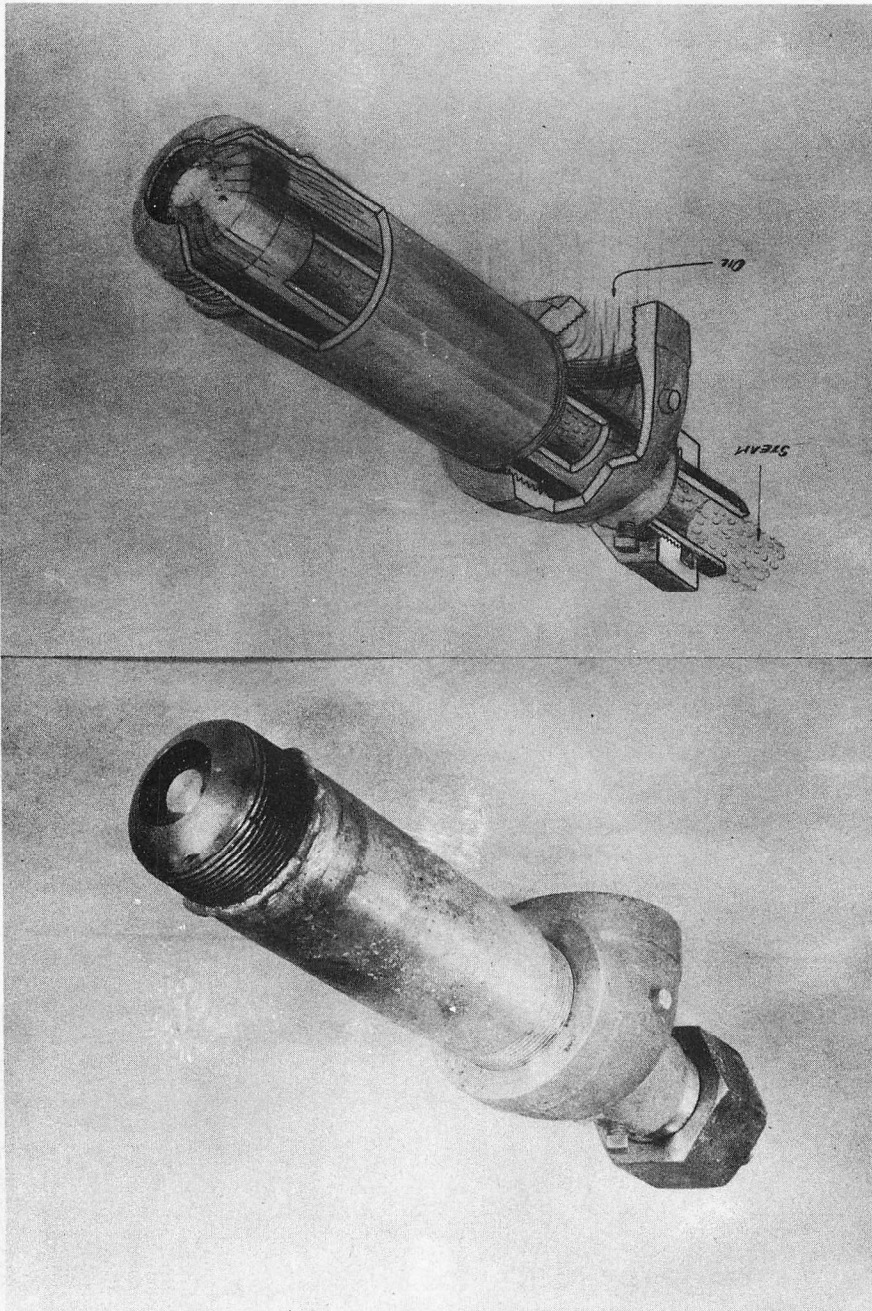


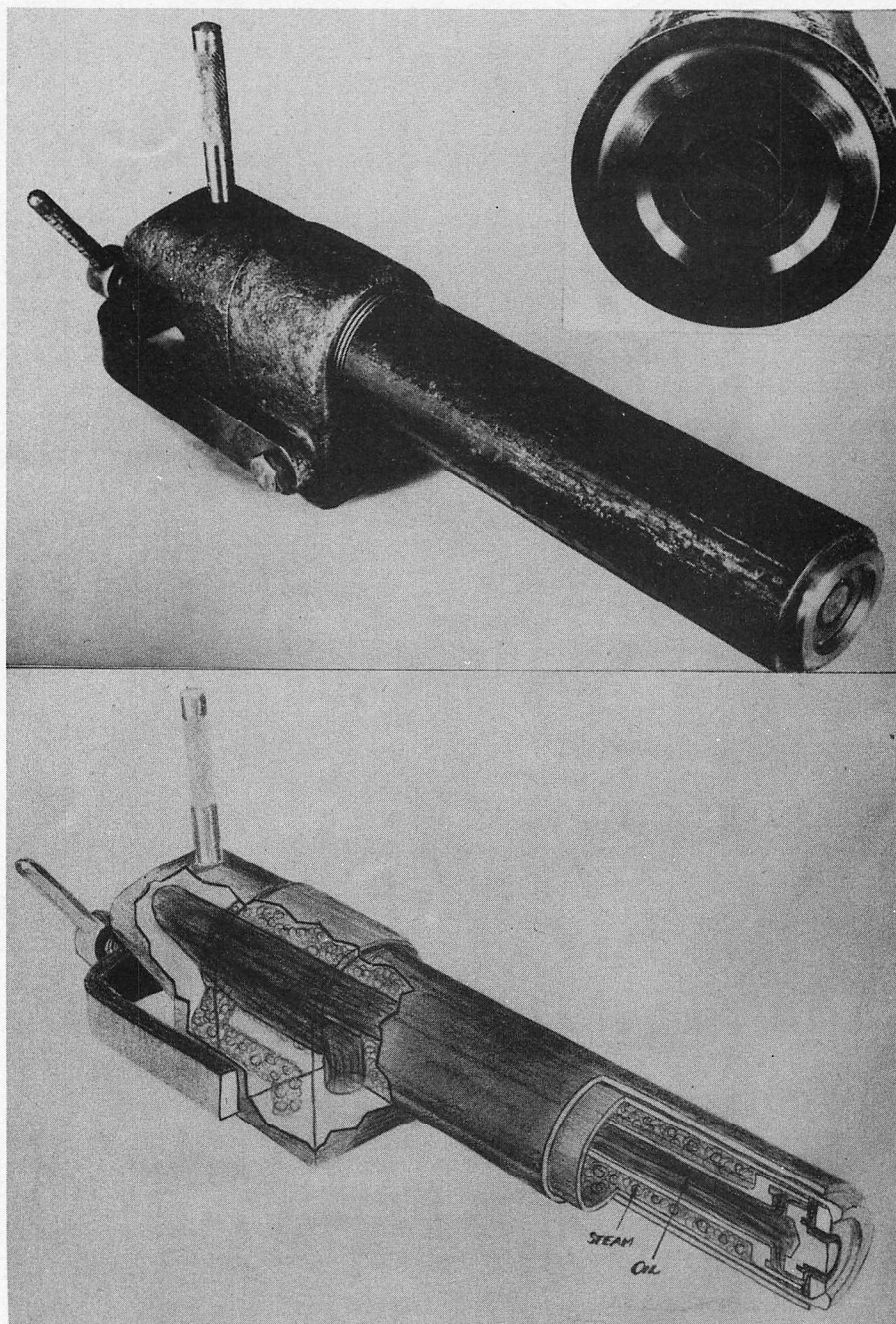
GYROJET BURNER

In this tubular burner the oil entered the central, reamed, oil passage gained some heat from the ambient steam and encountered the steam jets surrounding the oil outlet at the rear of the short, wide mouthed mixing chamber. The steam nozzles were machined so as to cause a rotational effect with the jets cutting across the edge of the oil stream and then sweeping the outer end of the combining chamber, the walls of which served to confine the oil to the steam spray, assuring good contact and preventing drooling from between the individual jets. Two styles of nozzles were tried, Style "A" being milled half round with the fit of the body completing the orifice, and Style "B" which were completely circular diverging nozzles. The small triply supported inner tube permitted free access of air to the oil passage at very low oil rates thus acting to prevent oil forming a vortex periodically with resultant spasmodic ejection from burner.

This was an experimental inside mixing type burner having a special provision in the design that allowed changes to be made in the length of the mixing chamber. The atomizing steam nozzle tip was removable to facilitate changes in that part also. The atomizer tip shown had ten $7/64$ " holes drilled at an angle to whirl the oil. The position of the tip relative to the burner outlet could be adjusted by releasing the set screw shown. Large nut at rear held the packing of the slip joint. Threads on front end were for trial of different style, secondary, burner tips.

CHAMBER TYPE TUBULAR BURNER

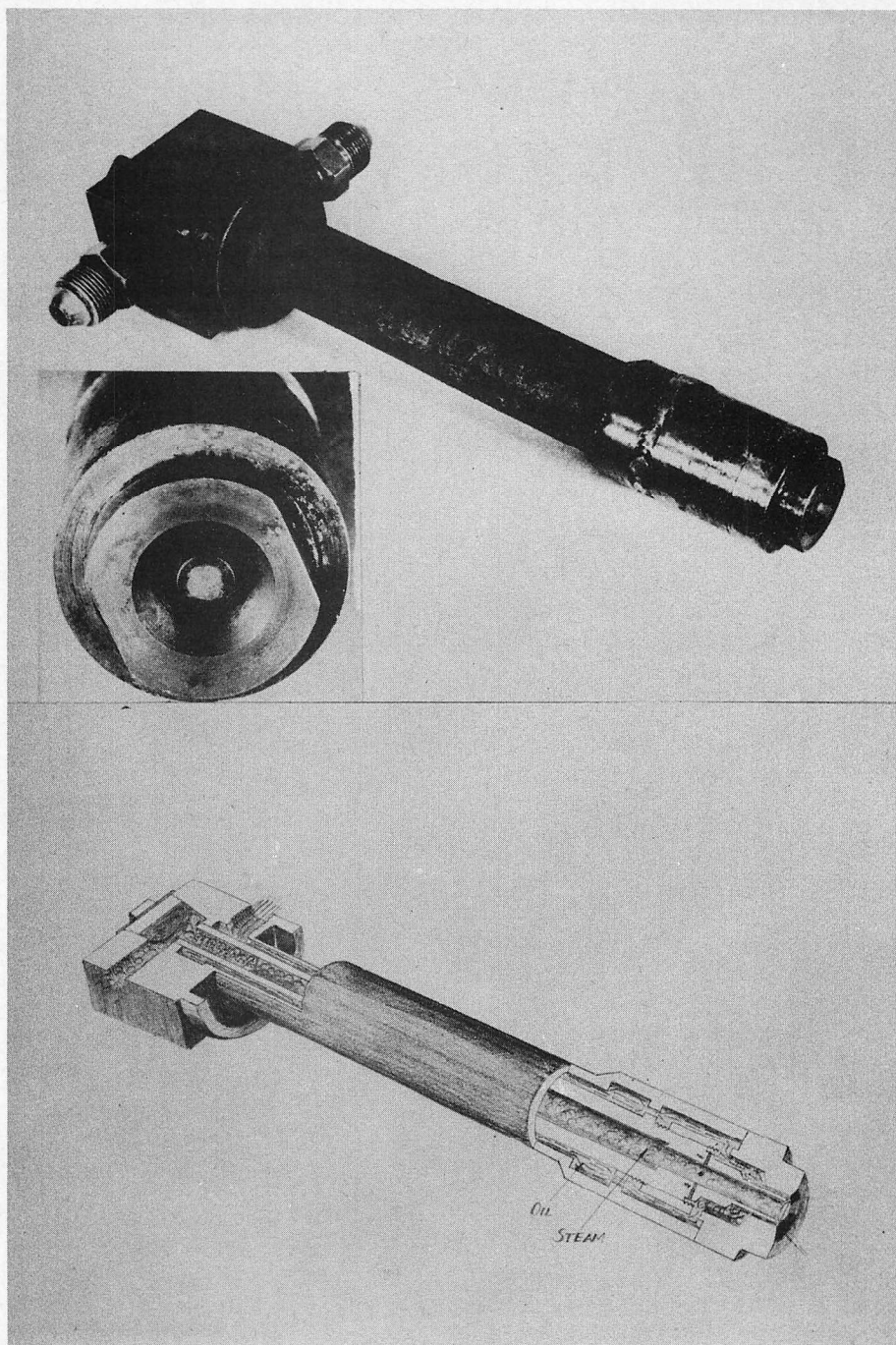




NAGEL "MICRONIZER" OIL BURNER

This burner is shown in the holder or mount of conventional style from which it could be removed for cleaning by releasing hand screw on stirrup and pulling on vertical handle. As shown, the steam in the burner proper, surrounded the central oil passage. It then entered the thinner annulus from which it passed into eight slots milled in the removable end plate. These slots were tangential to the outlet annulus. The oil also entered the slots from an annular passage which was of smaller diameter than that of the steam supply. The oil and steam then traversed the remaining length of slot together, to the annular swirl chamber and outlet.

Photo No. 5-20

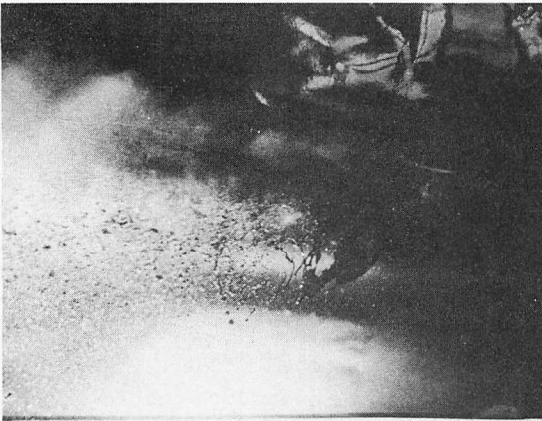


COEN BURNERS

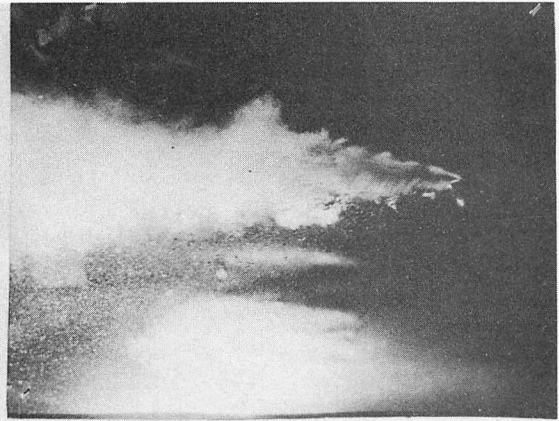
These burners were considered as entirely inside mixing since the steam jets were recessed in the end of the burner and atomization occurred within that recess. The atomizing steam first passed through fine mesh basket strainer at left end, then through central passage to burner tip, thus heating the oil in outer annular space. Main steam jets radiated conically from recess of tip but steam was also directed into oil swirl chamber through four very small holes. The oil entered the swirl chamber through two tangential passages then passed out through the thin annulus around steam tip where main jets completed the atomization.

This type has a thin flat steam slot with no lip underneath and the oil outlet is plain and straight. At the low rate the oil is visible issuing from the outlet in a weir type flow, falling onto the jet close to the burner face. While some large particles are visible at the start of the spray, the oil farther out is well broken up and the pattern shows good uniformity. At the high rate, the oil may be seen to be issuing in a strongly forward jet which, when contacting the higher velocity flat jet of steam, is thrown upwardly in great sheets and large globules. The pattern shows many large drops of sufficient size to run on the vertical surface.

2-1/2" BOOTH TYPE BURNER (T&P RY.)



HIGH OIL RATE



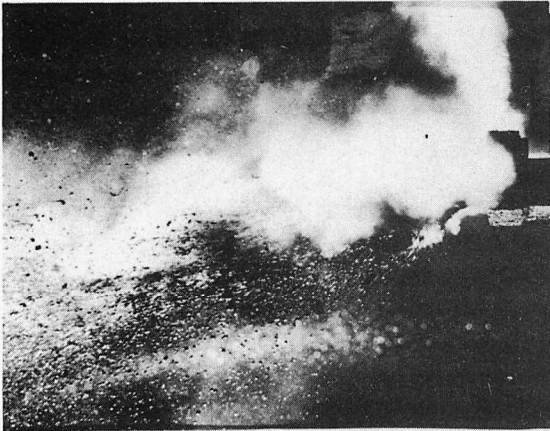
LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

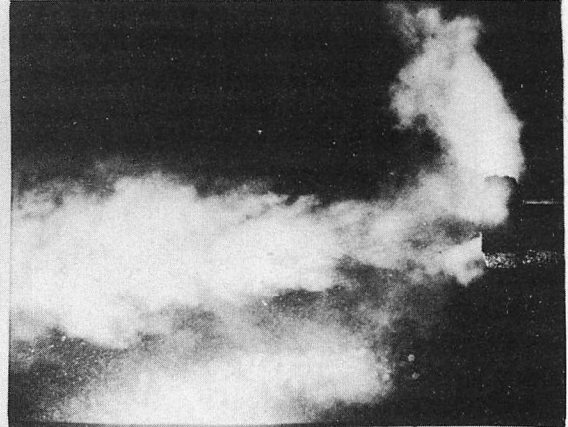


This Booth type burner had a removable plate to form the lower edge of the atomizer slot and difficulty was experienced in obtaining a steam tight fit between burner and plate which accounts for the downward jet and the obscured view of the high rate. The oil at the low rate appears well atomized but the pattern showed a tendency toward concentration which here is exaggerated through loss of the traces of fine spray in reproduction. At the high rate little detail near burner is visible through the vapor but pattern shows the spray to be heavy with very large particles.

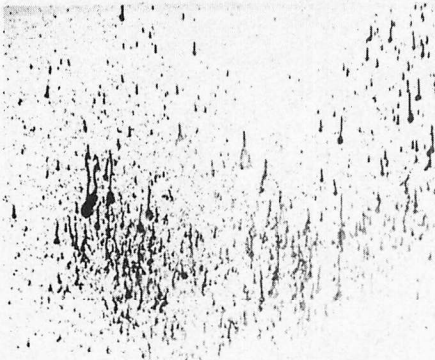
3" BOOTH TYPE BURNER (ST.LSW)



HIGH OIL RATE



LOW OIL RATE



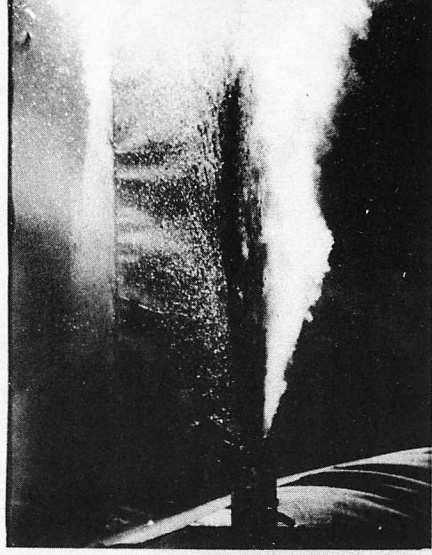
OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE

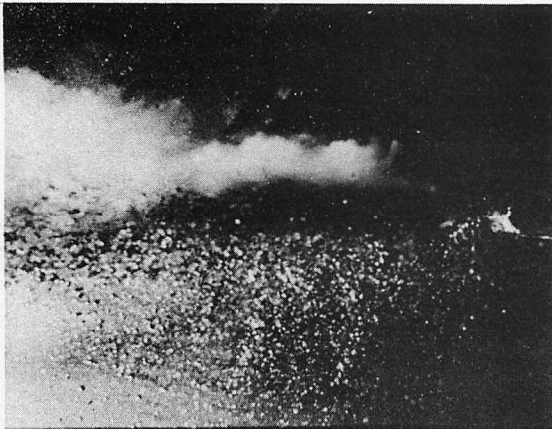


2-1/2" VON BODEN BURNER (PACIFIC LINES)

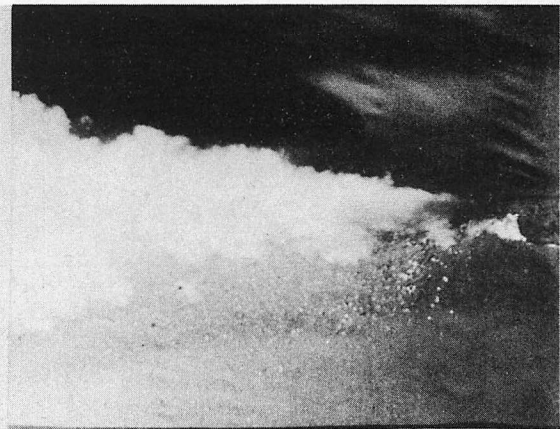
This was a 3" size standard burner reduced to a 2-1/2" size at the atomizing section for use during Dutch Oven tests because the standard 2-1/2" burner was too small at oil inlet and in oil passage for flow rates used. Although utmost care was observed in reducing size at outlet the standard design precluded precision finishing and some irregularity in the burner tip was no doubt the cause of the small oil flare at tip and large mass just out from tip that is visible at low rate when performance was normally best. At high rate, the effect of defect was negligible and spray and pattern appear normal for this style of burner.

This burner also was used in the test engine during trials of the Dutch Oven firepan arrangements and was tried just prior to the reduced burner, Photo 5-24. During the trials, this burner was positioned entirely outside of the firepan, permitting photographs of the oil spray near burner to be taken. These are on Photo page 5-49 and the effect of the high flying spray shown above is illustrated in those photographs by the heavy accumulation of oil above burner port. This upward oil spray and visibly unused lower portion of steam jet was characteristic of the steam slot, Von Boden type burners with corrugated lip. The pattern here at high rate shows less concentration than with most Von Bodens but this was the result of much of the upward spray not reaching pattern sheet.

3" VON BODEN BURNER (PACIFIC LINES)



HIGH OIL RATE

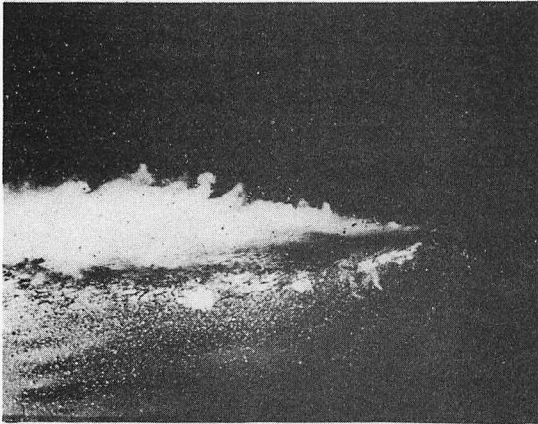


LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

This was a standard Von Boden burner in the size used in service and for the basic tests on the GS class of locomotives. The oil rates are therefore those encountered in service and from a service standpoint the burner was not overloaded as were the 2-1/2" and 3" sizes previously shown. These photos illustrate the atomization generally to be expected from the Bon Boden burner but as will be noted from these and succeeding pictures, the performance varies greatly from burner to burner because the design is not adaptable to precision finishing. Note at both low and high rates that while oil appears well broken up, there is a preponderance above the steam jet and much of the steam is apparently ineffective. Note at high rate, the concentrated area on right of pattern.

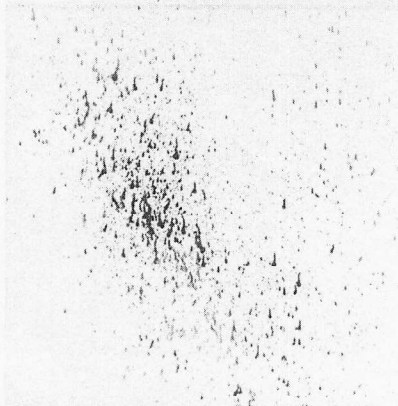
3-1/2" VON BODEN BURNER (T&NO LINES)



HIGH OIL RATE



LOW OIL RATE

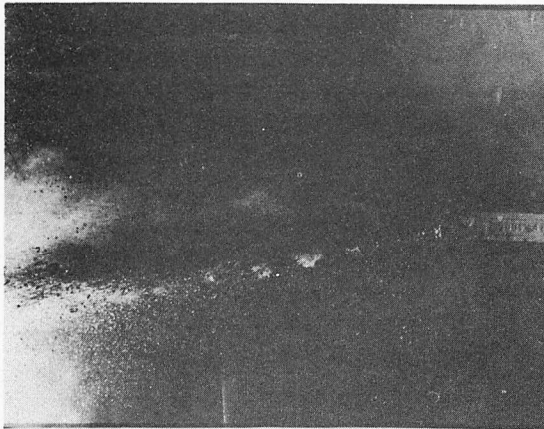


OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

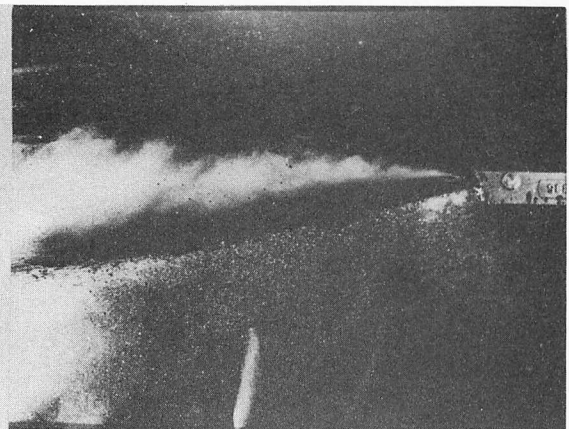


This burner was a standard Von Boden of the long style as used by the T&NO lines. In the photograph of the spray at the low rate the position of the back light has here exaggerated the appearance of the spray somewhat but the low angle of lighting does show a nearly complete absence of oil in the lower portion of steam jet. This serves to explain why the burner can be installed as low as 6-1/2" above firepan floor. Actually, in service, much of the high flying spray is deflected downward by the air through burner port. Note at low rate that oil reaching pattern sheet was of small uniform size but narrowly grouped, vertically. At high rate, this particular burner made a quite uniform pattern.

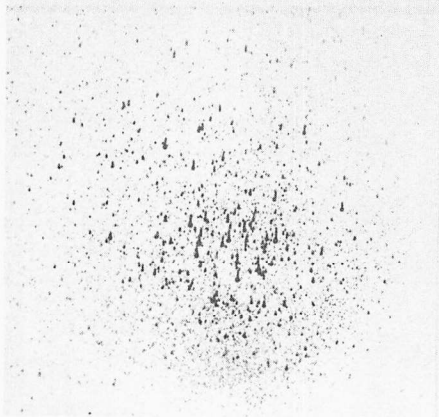
3-1/2" VON BODEN BURNER (T&NO LINES)



HIGH OIL RATE



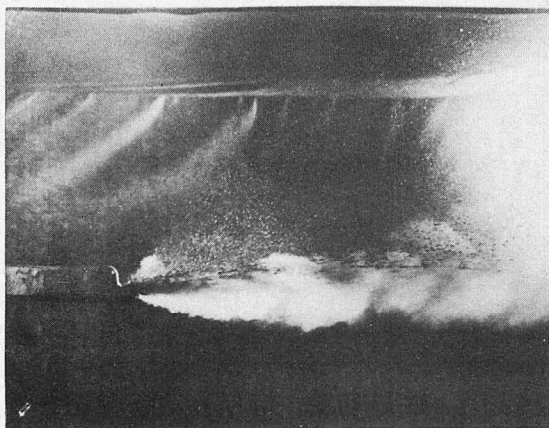
LOW OIL RATE



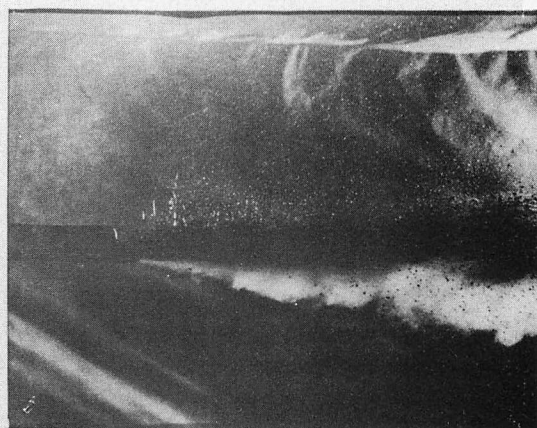
OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE

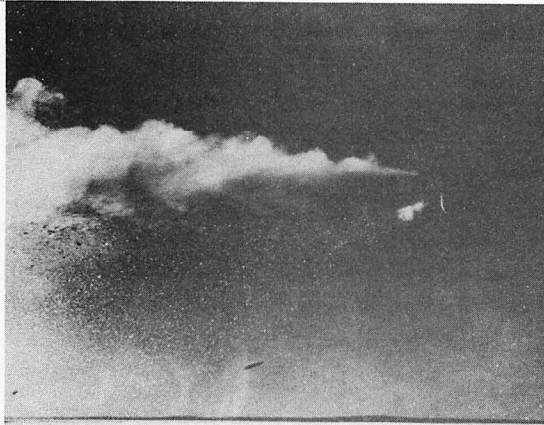


3-1/2" VON BODEN BURNER (PACIFIC LINES)

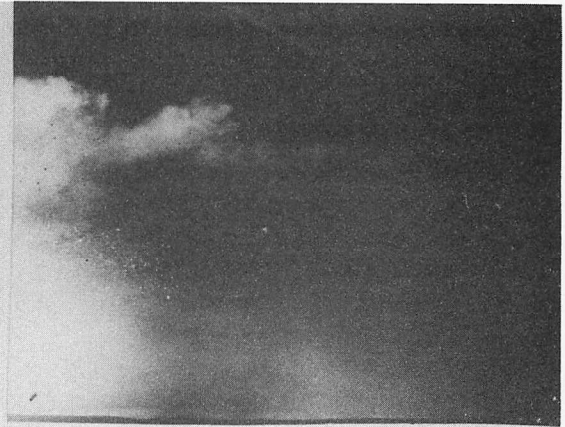
This was a standard Von Boden burner of the shorter style as used on Pacific Lines. The length of the body section was the only difference, the atomizing and oil outlet portions of both Pacific Lines and T&NO Lines burners being to the standard Bon Boden design. However, some differences in performance could result because of the different sources of manufacture and the fact that the design is not adaptable to precision finishing. With this particular burner the main jet of oil was somewhat lower and more in line with the steam jet than in others. At the low rate, considerably more oil than usual reached the pattern sheet and the particles were well dispersed. At the high rate, this burner had a somewhat semi-circular area of large particles.

This burner was another standard Von Boden of regular manufacture. At the low rate, the spray was not well lighted but many large globules of oil may be seen dropping in the lighter areas of the vapor cloud. Note that pattern shows that considerably more oil reached the target sheet with this burner than with others. At the high rate the upper portion of the jet in the dark areas, contains the main oil spray but the velocity of those particles was too great to be stopped by the photography. The results are visible, however, on the pattern. At the high rate this burner had an excessively heavy, concentrated, oil jet as shown by solidly covered portion of the pattern, the top part of which is a gray shade due to reflection of light.

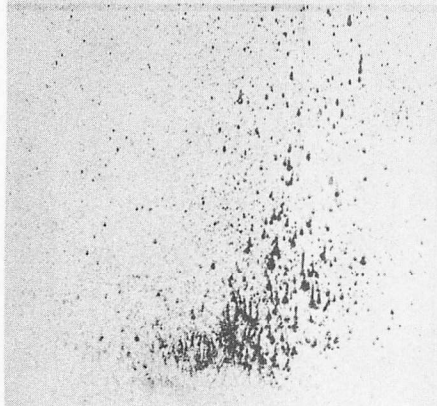
3-1/2" VON BODEN BURNER (PACIFIC LINES)



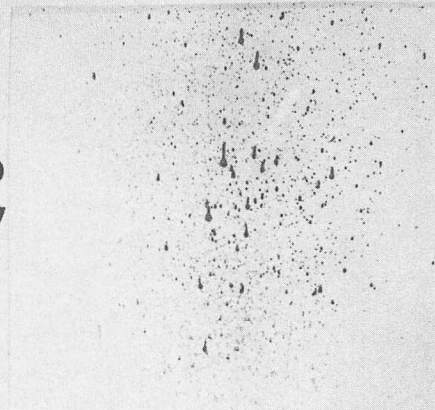
HIGH OIL RATE



LOW OIL RATE

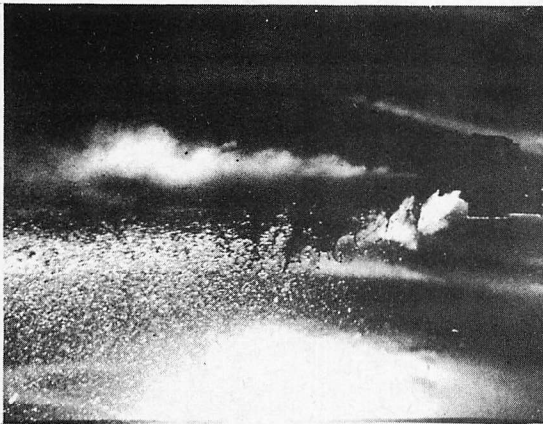


OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

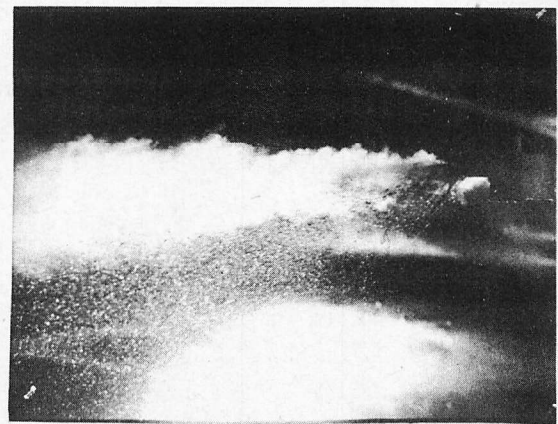


This burner was essentially a Von Boden with a renewable corrugated lip, a portion of which also formed the lower edge of the atomizing steam slot. There were some differences in that the outer edge of the corrugated lip was straight and not semi-circular as in the true Von Boden; also the oil outlet was tilted out straight, in line with burner axis. As with the regular Von Boden, photographs at both rates show the high flying spray. In addition, heavy sheet-like masses are visible at the spray near the start. The similarity in appearance of this area to that for other flat type burners having oil and steam flow parallel at outlets indicates this deficiency in atomization was characteristic of that type oil outlet. The effect of the practically parallel flow may be compared, but in reverse, to "skipping" a flat rock on water. Here, instead of the fast moving rock glancing from a body of water, the relatively slow moving oil glances off the high velocity steam jet and is not sheared and broken up as it would be if the angle of approach were greater.

VON BODEN TYPE BURNER (SSW)



HIGH OIL RATE



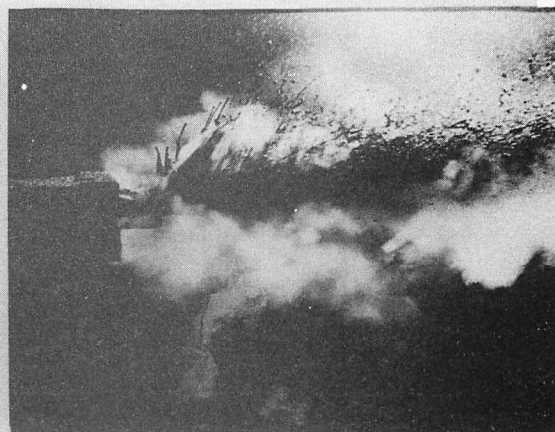
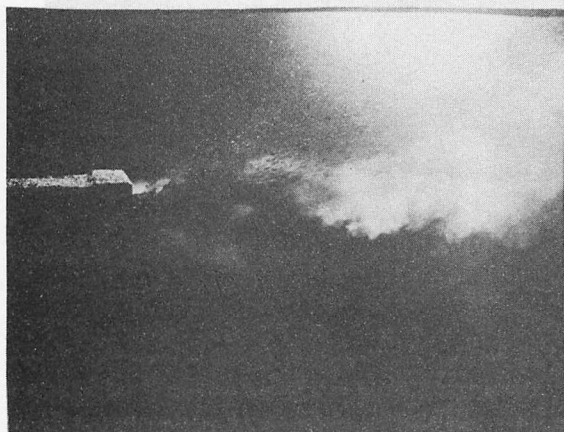
LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE

HIGH OIL RATE

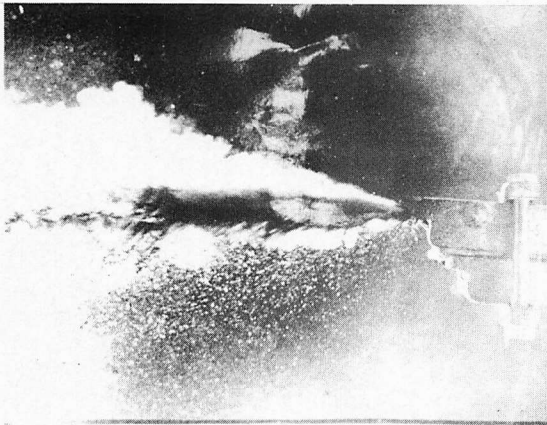


VON BODEN TYPE BURNER (SSW)

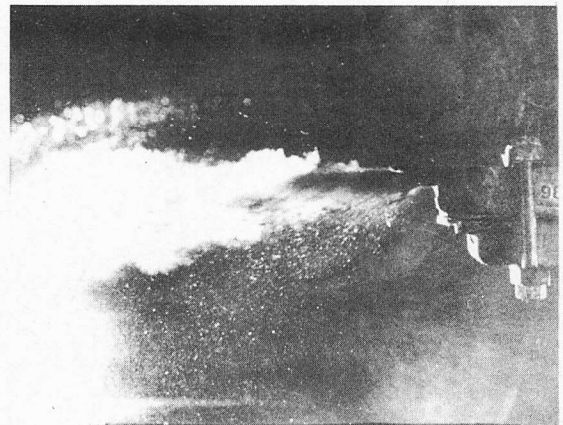
This was the same burner body as on photo page 5-27-A but the removable corrugated lip was of different manufacture (Magnus, as compared with Edna, in the previous photo). The only appreciable difference noted was that the side wall on the above lip extended full height the full length of the lip whereas the other lip had the end of the side walls rounded. With this lip there was, as may be observed, much more oil reaching the spray pattern sheet than with the other lip but the reason was not evident. There was some leakage of steam at the joint between lip and body but the lighting on the spray at the high rate, was such that the mechanism of formation is quite clear. Note the flat angle of the oil stream and its curve up into the tendrils and sheets of oil.

This was a standard 3-1/2" size Von Boden burner that had the bottom of the oil passage cut away, particularly at the curved outlet surface so as to form a shallow Vee shape which would center the oil flow at low rates. This was an attempt to reduce the side flow of the oil in service in curved territory and to prevent the wandering of the oil stream that was noted at low flows during engine tests. These pictures were taken while the burner was clamped together with another on top in order to try later, the effect of an over-spray steam jet, but this had no bearing on the results pictured here because no steam was admitted to the top burner and it was set back so as to not interfere otherwise. With this burner more oil appears to have been actually entrained in the steam than was usual for the Von Boden. However, there is no certainty that this or the heavy concentration on pattern at high rate was caused by the Vee, because of the wide variation between standard burners as previously brought out.

VON BODEN BURNER WITH SHALLOW VEE OIL PASSAGE



HIGH OIL RATE

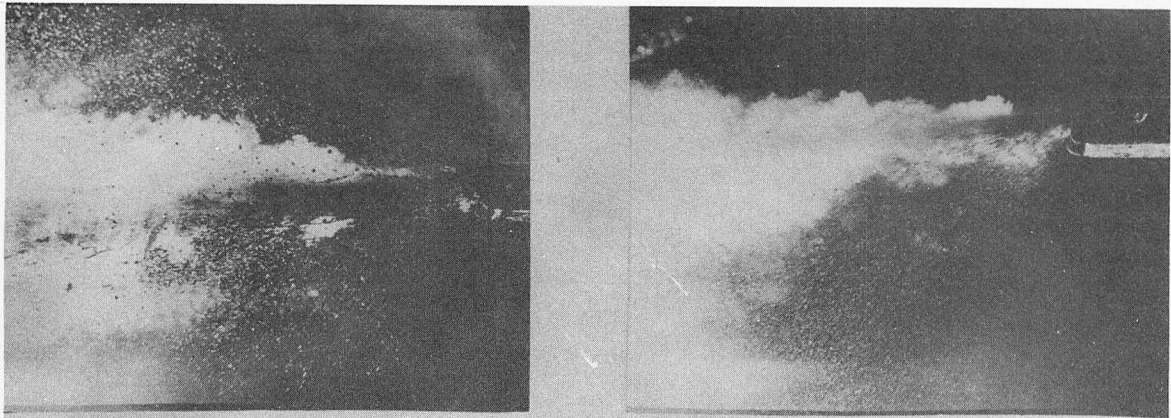


LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

This burner was a standard 3-1/2" Von Boden on which special high walls, with vertical corrugations, were brazed at the sides of the corrugated lip, replacing the low walls of the standard design. The exact purpose or function of the extended walls was not apparent but they probably were intended to confine the oil stream to the steam jet, as in the standard design, slight misalignment of core in casting can result in oil slot extending an appreciable distance beyond steam slot. The oil could then drool over edge of jet and burner, with the standard low walls on the lip. At the low rate, this burner had a strong upward spray with some particles moving at nearly a right angle to the burner axis. At the high rate, the spray picture shows a general scatter of oil in all directions and from the pattern it is evident that the spray contained many large globules of oil.

VON BODEN BURNER WITH "WALLED EXIT"

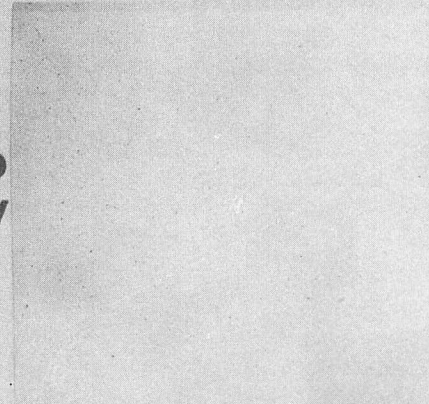


LOW OIL RATE

HIGH OIL RATE

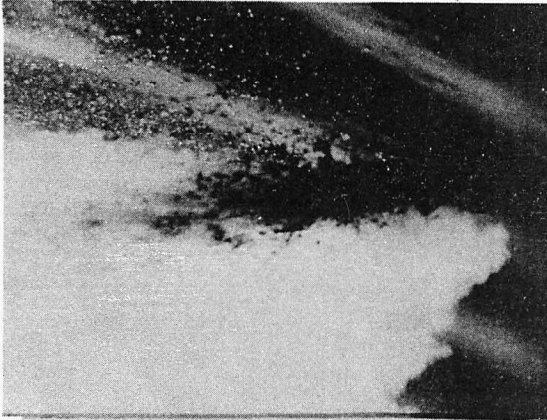


**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

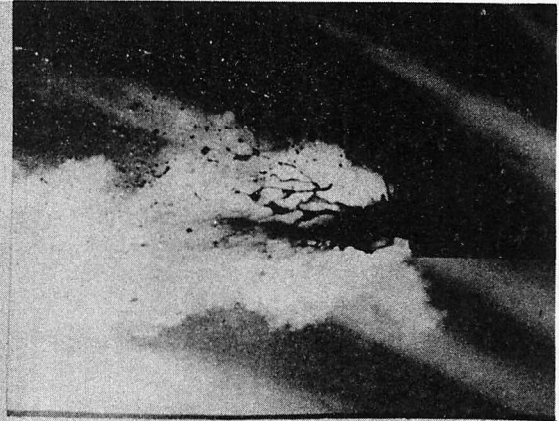


This was a standard Von Boden burner which had been modified by application of a 11/16" wide, metal strap to obstruct the center portion of the atomizing steam jet and the oil stream. The strap extended from the top of the burner out and down to the tip of the corrugated lip and the effect of thus obstructing the steam jet may be noted in the spray photographs above, showing a reverse jet of steam. Wind conditions on day of these tests blew vapor cloud to far side of burner, disclosing in good detail the nature of the oil stream near burner. The atomization obviously was poor, yet the spray patterns show a more uniform distribution and drop size than some of the standard Von Bodens.

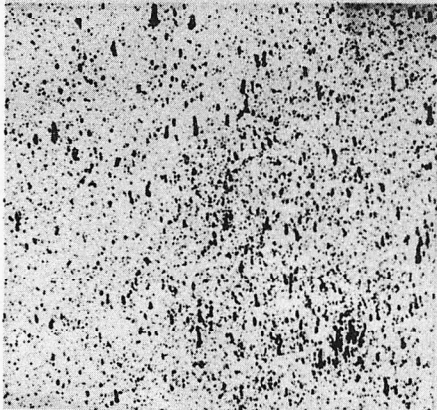
VON BODEN BURNER "STRAPPED"



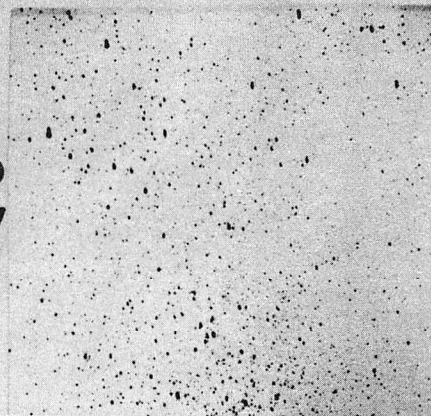
HIGH OIL RATE



LOW OIL RATE

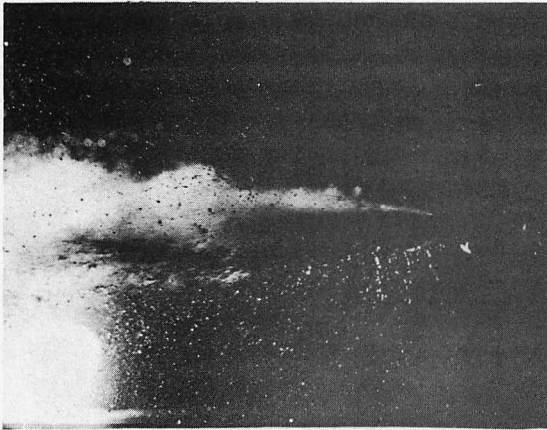


OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

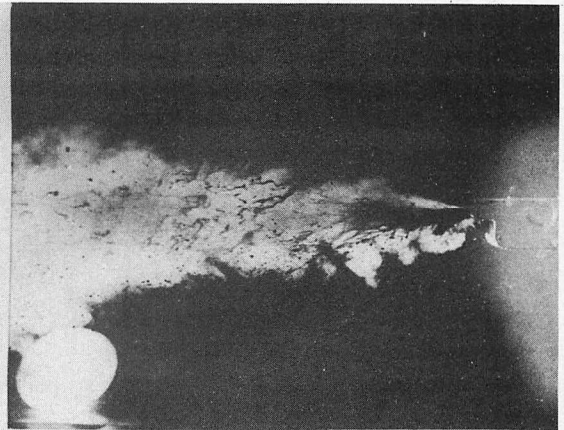


In this modification of the standard Von Boden burner the only change was in the oil passage. Two separating strips were appropriately applied in the burner to divide the original width into three oil passages. The outer two received oil from the lower pipe connection and the center alone was fed from the top inlet. For these tests the center passage only was used at the low rate but at the high rate oil issued from all three. For both rates, the full width of steam was used as there was no modification made to the steam portion. The spray at the low rate was visibly not good and the pattern shows many large particles of oil. At the high rate the spray appears normal for the Von Boden burner although the change in the oil passage alone, could not be expected to affect the high rate performance.

VON BODEN BURNER WITH DIVIDED OIL PASSAGE



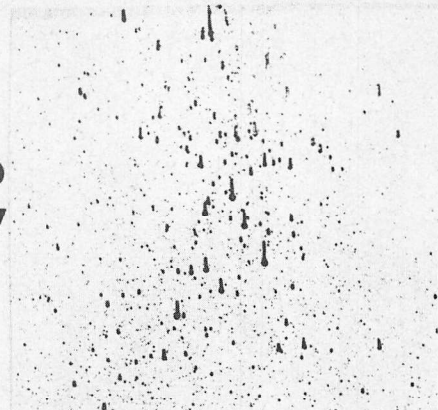
HIGH OIL RATE



LOW OIL RATE

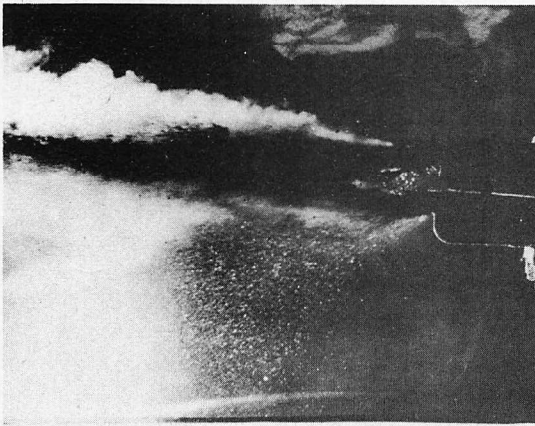


OIL SPRAY PATTERNS OBTAINED AT DISTANCE OF EIGHT FEET FROM BURNER

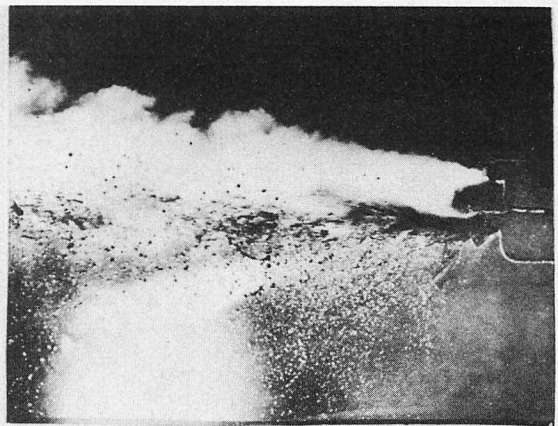


This arrangement was a combination of the 3-1/2" shallow Vee Von Boden burner and a 2-1/2" standard burner which was placed on the top for use at low rates. The oil flow to the two burners was controlled separately but the steam was not, as may be seen. Hence at the low rate the lower steam jet affected the atomization, drawing the upper spray downward as may be seen. The pattern at low rate shows uniform coverage with a good range of particle sizes and but few large drops. At the high rate the top burner of course still threw some oil upward but it will be noted that the large masses from the lower burner are trapped between the jets and enter the two which combine because of the low pressure area developed between them. At the high rate the pattern here appears sparse on the left but actually it was not and the appearance was caused by the loss in detail of the small spots in the reproduction process.

VON BODEN BURNERS, DOUBLE

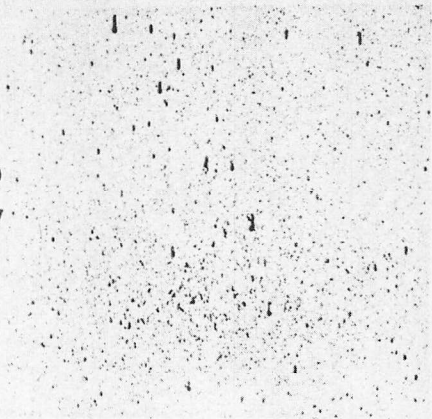
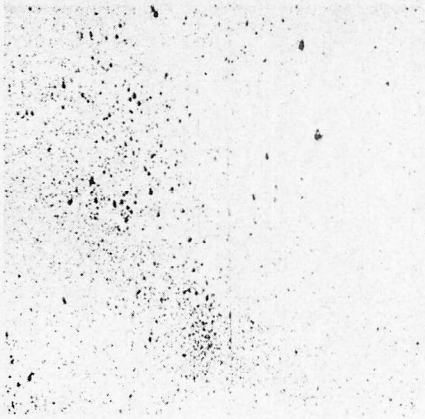


HIGH OIL RATE



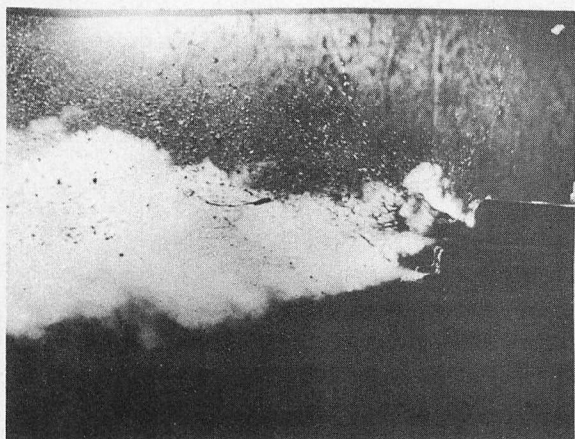
LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

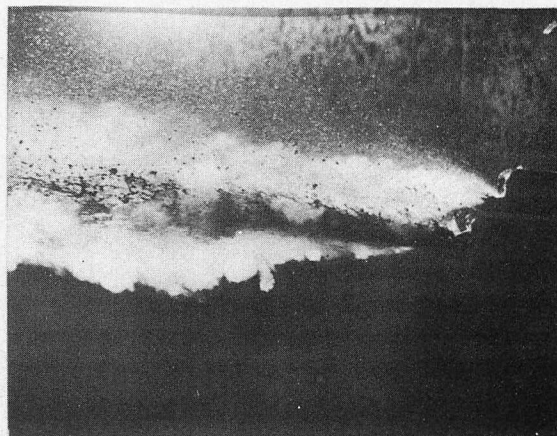


**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE

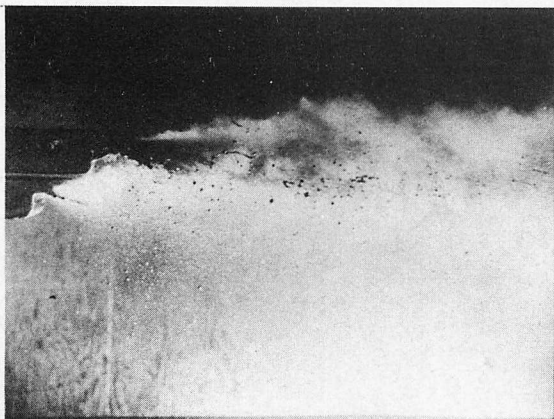


VON BODEN BURNERS, DOUBLE

This was a second position in which the combination of a 2-1/2" Von Boden burner on top of a 3-1/2" size, was tried. In this position the end of lip on the top burner was flush with the face of the oil outlet of the lower burner. At the low rate oil was supplied only to the top burner but steam was supplied to both. At the low rate the appearance of the spray is not commendable and some oil appears to be rising vertically from the burner although the angle may have been exaggerated by the camera view point. At the high rate oil was fed to both burners and with the higher atomizing steam pressure used the spray from the top burner improved. At the high rate the jet from the top burner was effective in holding the lower spray down but heavy masses of oil are visible in main stream at left, a considerable distance out in the spray. The pattern shows a tendency for concentration of large drops of oil on the right of the jet.

The 2-1/2" standard burner on top of the 3-1/2" burner was also tried in this position in which the tip of top burner was set back 1" behind face of oil outlet of bottom burner. At the low rate the oil spray, which is from the top burner only, appears broken up better than in other positions but the cause was not evident. Neither was the reason apparent for the smaller amount of oil reaching the pattern sheet although the pattern here appears slightly sparser than actual, due to some of the smallest spots being lost in the reproduction. At the high rate, oil was sprayed from both burners and the oil was quite well broken up in both streams with somewhat better than usual entrainment in the steam occurring. This better entrainment may account for the small amount of oil reaching the pattern target as similarly occurs with burners having multiple steam jets.

VON BODEN BURNERS, DOUBLE



HIGH OIL RATE



LOW OIL RATE

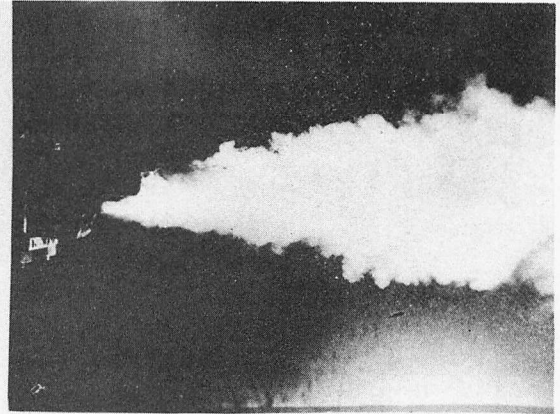
OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

Here the upper and lower burners are in same position as in photos 5-34, that is with tip of top burner set one inch behind face of oil outlet of bottom burner, but in this instance the lower burner as well as the top, was a standard Von Boden without the shallow Vee modification previously illustrated. In these pictures, the upper burner was used only to provide an over-spray steam jet and no oil was fed through it. At the low rate oil can be seen falling from the spray close to the burner. Visible also, but on close inspection only, is oil dripping from tip of lip. Both these effects were probably the result of the design in which the oil outlet is the same size transverse to the burner as the atomizing steam slot, and actually, because of irregularities in the cast-ings and difficulties of machining, the oil slot may slightly over hang the steam slot. The appearance of the spray here, indicates some such condition existed, causing the effects noted. At the high rate the spray appears poor and the pattern while better than some, shows an unsymmetrical concentrated area on left.

VON BODEN BURNERS, DOUBLE



HIGH OIL RATE



LOW OIL RATE

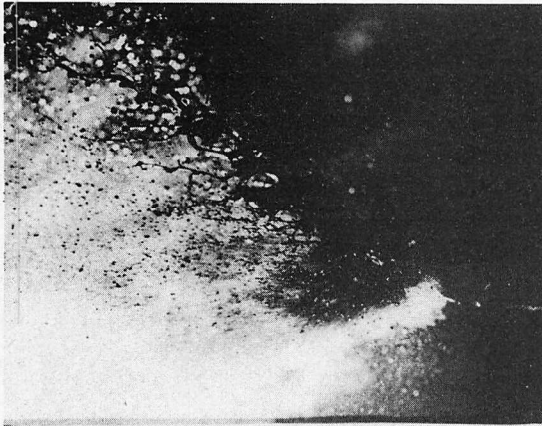


OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

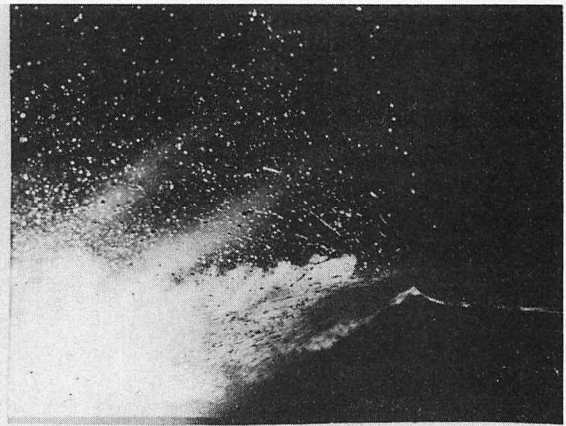


This burner was made from a standard Von Boden by applying a hood extension over the oil outlet and by cutting the steam slot at an angle upward so that jet would sweep past the edge of the hood extension. The sides of the extension of the oil passage were left open and it will be noted in photographs of the spray that a considerable portion of the oil came out of the burner through the side exits. Spray patterns were not obtainable with this burner.

VON BODEN BURNER ASPIRATING MODIFICATION



HIGH OIL RATE

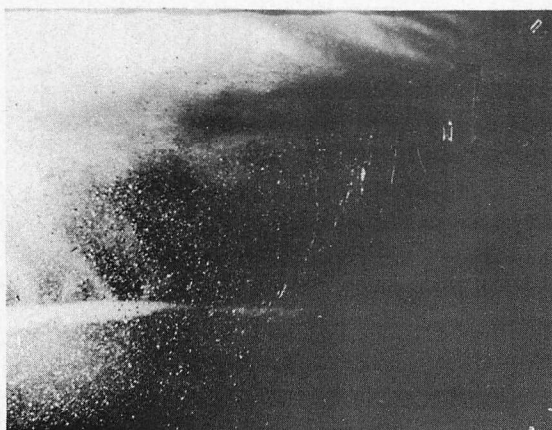


LOW OIL RATE

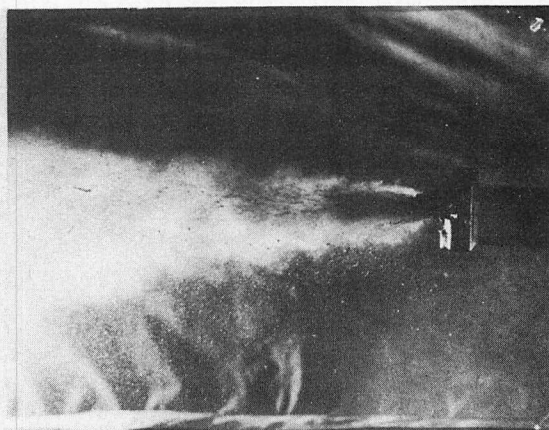
OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

This burner employed one of the most notable variations from the usual flat flame, drooping design to achieve improved performance. Here, the steam jet was from multiple circular nozzles, radiating out of a semicircular portion of the removable lip over which the oil flowed from the downwardly directed oil outlet into the jets at their start. The lip held the oil from running down between the jets and several recesses increased the accessibility of the under part of the steam surface. The lower than usual camera angle exaggerated the upward spray but it will be noted that some large masses were present at the high rate. The low camera position was selected however to better record the conditions in the main spray in which the major portion of the oil was entrained at high velocity as indicated by the streaked, gray appearance. The patterns were uniform, but sparse because with the oil entrained and not riding on the steam jet, it did not carry to the target sheet. Also, the wide spray from the radiating jets spread the oil over a greater area, reducing the amount on the target.

GREAT NORTHERN BURNER



HIGH OIL RATE



LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE



CHICAGO, ROCK ISLAND & PACIFIC BURNER

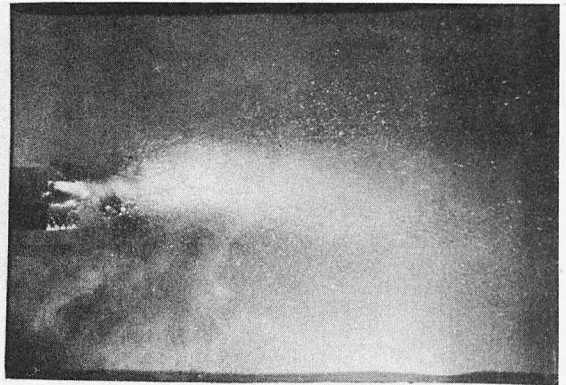
This burner also employed radiating, multiple, circular, nozzles for the atomizing steam but their outlet was in a shallow recess under the straight, milled oil outlet. The oil therefore contacted the steam jets at an acute angle, as in the Booth burner, and, particularly at high rates, out an appreciable distance from the face of the atomizer outlets, the effect of which may be noted above. Here also, due to the entrainment of oil in the multiple jets, the majority of the oil may be seen to be in the steam jet and at the low rate, some may be observed below the vapor. The spray patterns also show the effect of the multiple jets, as little oil reached the pattern sheet in these instances where atomizer pressures were the same as used with flat-slot type burners which merely hurl the oil upward and hence utilize less of the energy of the steam jet. To compensate for the different nature of spray from multiple jet type burners these types are customarily placed higher in firepans than the Von Boden burners for example, thus avoiding oil on the floor brick.

This burner had an oil outlet and oil passage such that the cross section was a series of slightly overlapping diamond areas. Here, the lower steam jets issued directly under the lower point of each diamond area. These, and the five smaller jets above the oil outlet, radiated outwardly over a total included angle of 30°. The upper jets were normally quite effective in preventing the heavy upward flying masses of oil and it is possible that through some inadvertence at the low rate the pressure to the upper jets was improperly adjusted or the oil flow was more than the usual rate. At the high rate the upper jets may be noted to have had a marked effect. Although the lighting of the spray did not bring out the characteristics plainly the length of the stream of oil from the outlet is visible and some large size oil particles may be observed in the spray. As with other multiple jet type burners, the character of the spray would improve with increase in steam pressure. At both rates the spray patterns were uniform with no excessively large globules and show evidence of much fine spray.

MULTIPLE DIAMOND CHANNEL BURNER



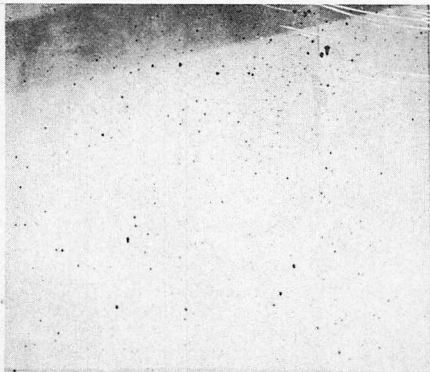
HIGH OIL RATE



LOW OIL RATE

OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER





LOW OIL RATE



**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**



HIGH OIL RATE

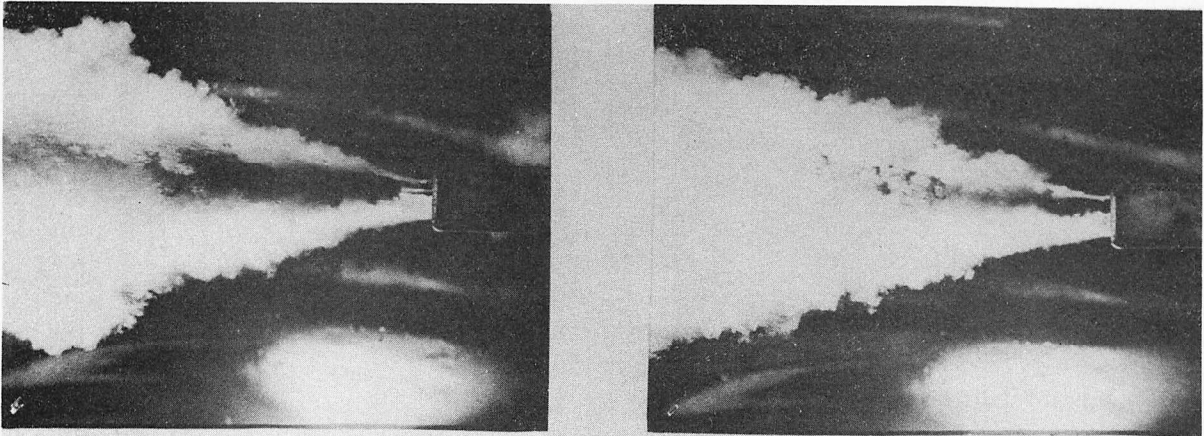


MULTIPLE DIAMOND CHANNEL BURNER

These pictures show the performance of the burner with the lower steam jets centered under the thin portions of the oil outlet where the diamond shaped sections overlap. The same five upper steam jets were used and it will be noted that at both rates the upward spray is minimized and that spray appears quite symmetrical and uniform vertically. The spray patterns here again, show good uniformity both vertically and horizontally with much evidence of fine spray, but in general those obtained with the jets centered under the heavy sections of oil flow, that is, under the lower point of the diamond, were better. Additional trials not illustrated of the two main steam jet arrangements, and closer but visual examination of the atomizing action confirmed that the better results were obtained with jets centered under the heavy sections of oil flow than with this arrangement. This was due in part to there being 10 jets as compared with 9 here, which in addition to the advantage of the extra jet, gave better coverage of the oil stream.

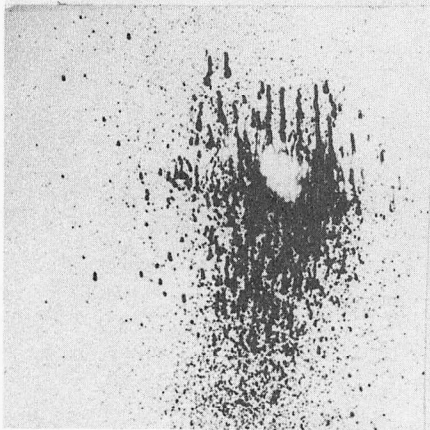
This burner was designed to eliminate all erratic scattering of oil through the use of multiple steam jets arranged in a rectangle entirely surrounding the narrower rectangular oil outlet. As may be noted, the design successfully prevented scattering but was too effective, causing excessive concentration of the oil spray. It will also be noted that the upper jets appear to have been placed too high above oil outlet and that consequently much of the steam from those jets did not participate in the atomization.

BURNER WITH MULTIPLE JETS IN RECTANGLE

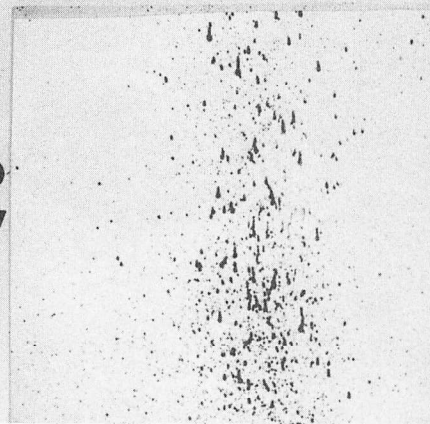


HIGH OIL RATE

LOW OIL RATE

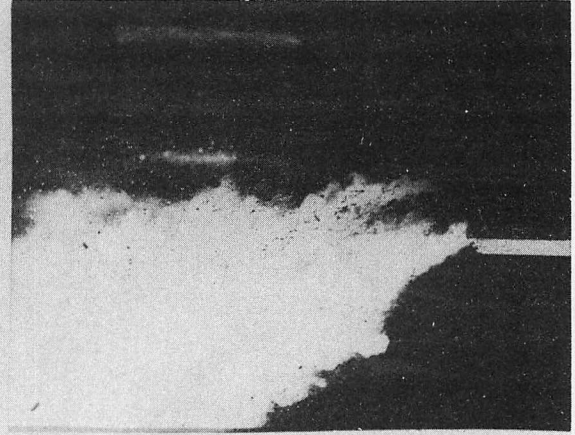
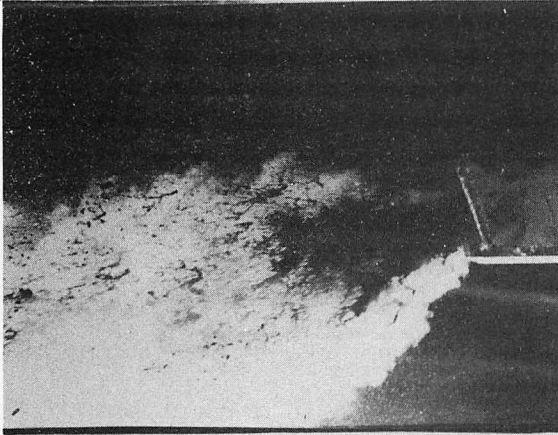


OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER



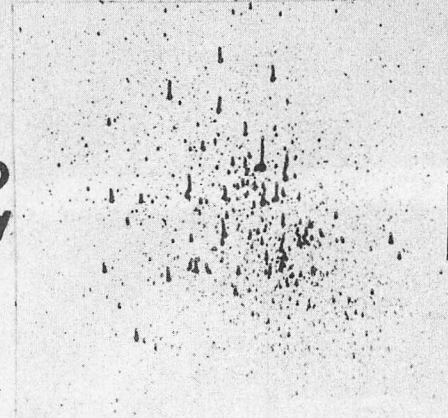
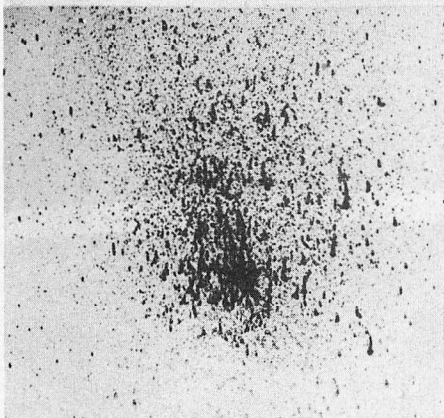
This burner was in effect, three small capacity burners, each with an individual oil outlet and atomizing jet, mounted in one block which supplied oil to all three from single exterior connections for oil and steam. All three steam jets and oil outlets were therefore in use at all rates. It will be noted that the spray issues from the burner at an upward angle, perpendicular to the steam orifice plate and that much of the steam was ineffective. The patterns show evidence of many large particles of oil and considerable concentration.

MULTIPLE VEE CHANNEL BURNER



HIGH OIL RATE

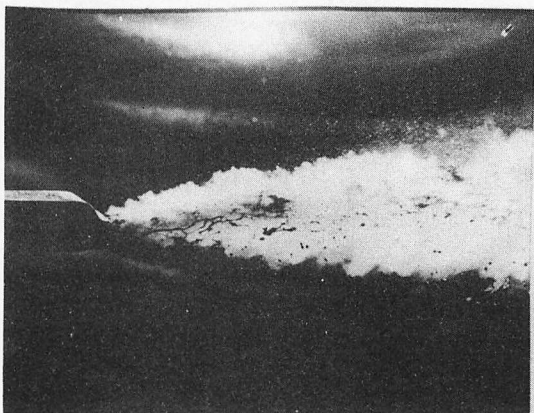
LOW OIL RATE



OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



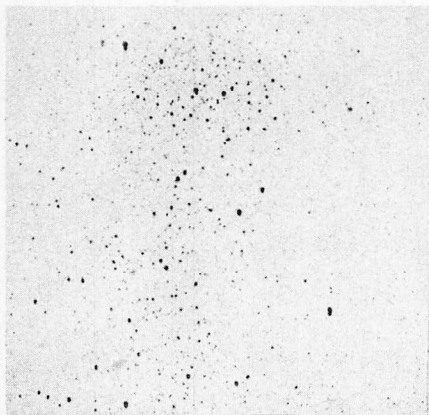
HIGH OIL RATE



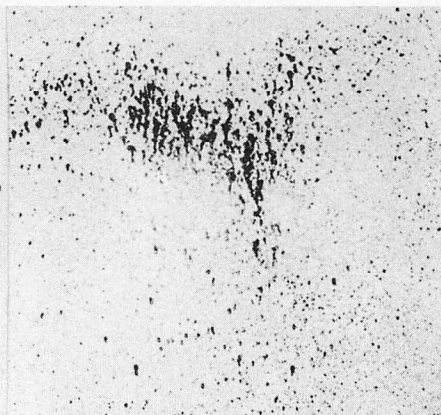
SHEEDY OIL BURNER, NOT MODIFIED

This was an inside mixing burner, patented in 1899 and at one time used on Southern Pacific Lines before the change was made to use of residuum type fuel oil. In this unmodified burner, the atomizing steam issued from a long thin slot approximately the length of the rectangular outlet of the burner. Oil entered the chamber from above the steam jet. Air could also enter the mixing chamber from a passage below the steam jet. The pictures of the spray show the atomization was poor and long thread-like masses of oil are particularly noticeable. These also occurred in the spray from some of the other inside mixing type burners tried. The patterns both have a heavy centralized concentration. Prior to the cold tests illustrated, trial in the test locomotive had shown this burner to be very difficult to fire because of poor atomization and excessive sensitivity to changes in atomizer pressure.

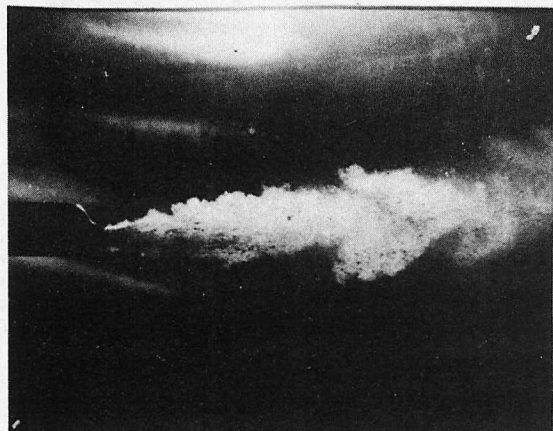
**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**



LOW OIL RATE

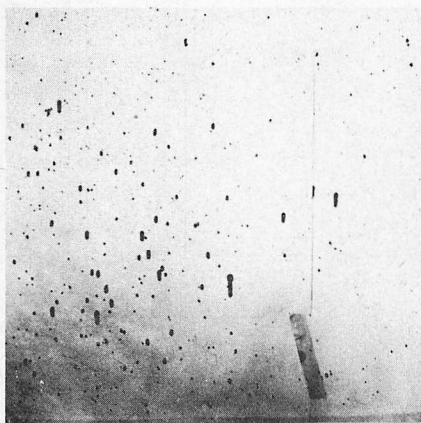


HIGH OIL RATE



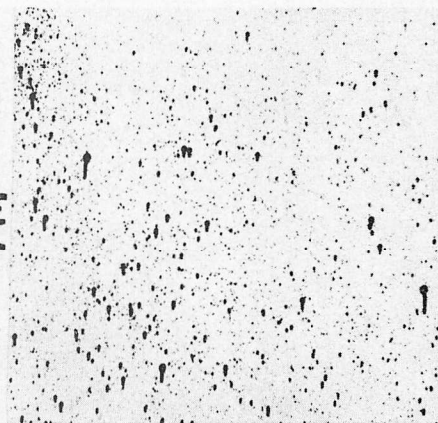
SHEEDY BURNER, MODIFIED

This was the standard design of Sheedy, inside mixing burner with the exception that multiple expanding nozzles of corresponding total area were used for the atomizing steam, in place of the long thin slot of the standard design. These pictures and those for the unmodified burner on preceding page illustrate very well the advantage of multiple jets over slot type atomizing orifices, for between these burners there was but that one difference. Although the oil spray from this modified burner was visibly superior, which also was found during trial in test locomotive, the atomization was still incomplete as may be noted at high rate, particularly. Patterns show some heavy particles in the jet at the low rate and an eccentric concentration at the high rate.

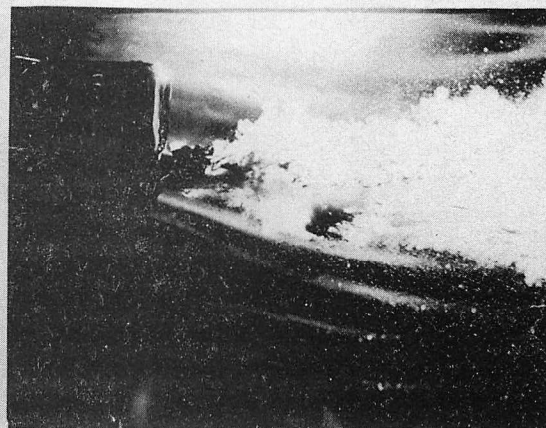
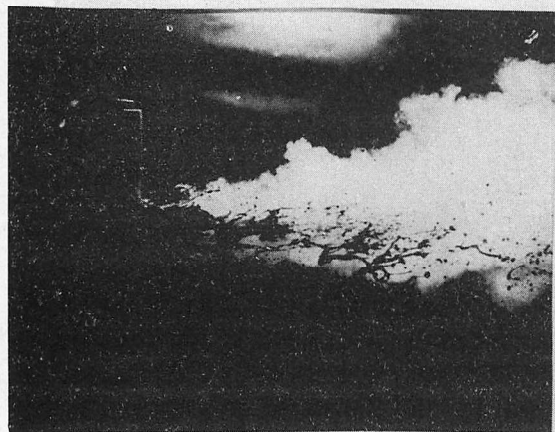


LOW OIL RATE

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**



HIGH OIL RATE

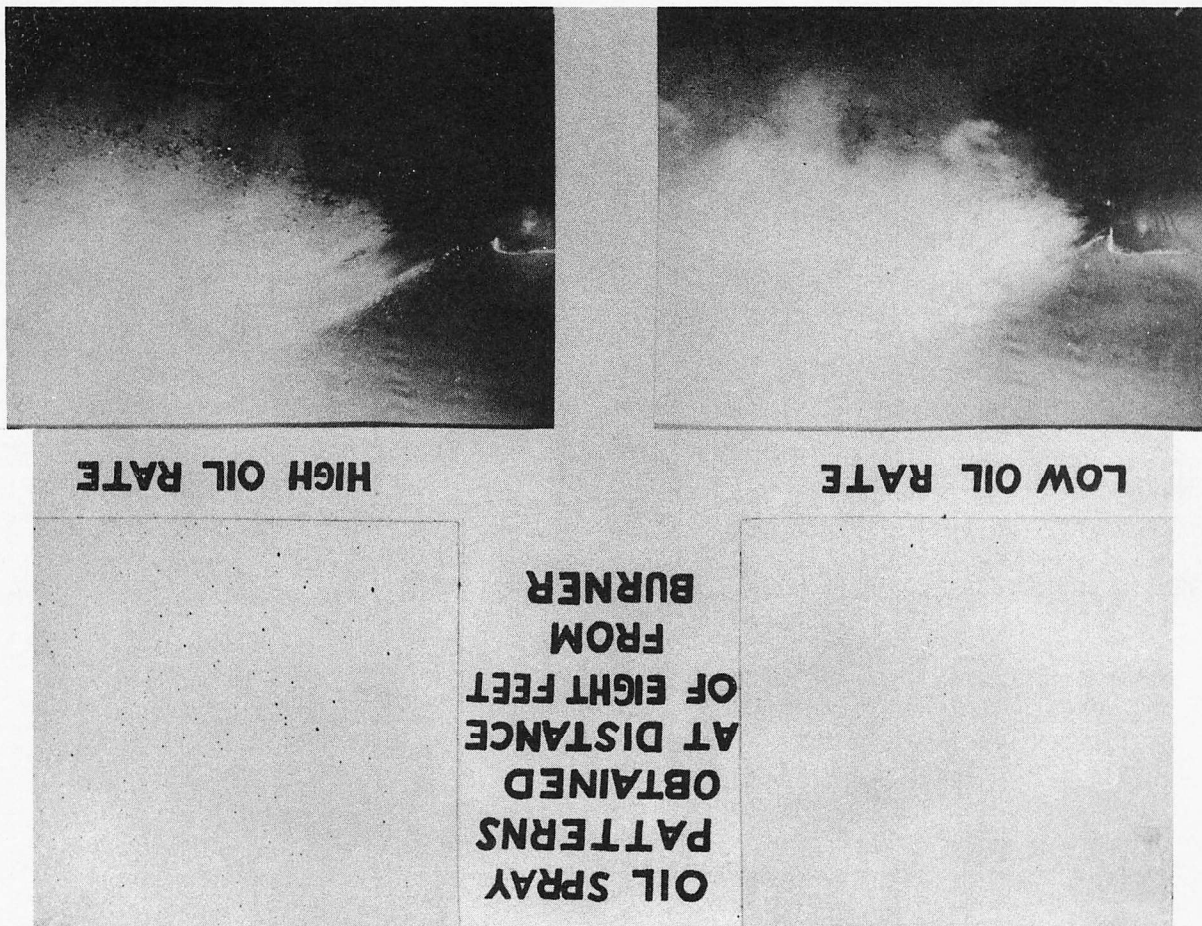


BRITTAIN BURNER

In this inside mixing burner the oil flowed from a loosely covered reservoir in the large head of the burner through Vee notches in the top of a riser and thence onto the jet from the flat slot atomizer orifice. The atomization was very poor, as may be seen, and as with some few other burners, much of the atomizing steam appears to be wasted. This burner also proved to have inadequate capacity as shown by the picture of the spray and burner at the high rate where oil flowed out over the top of the reservoir past the loose cover. The spray patterns show a general uniformity, but large particles, and it may be noted in the spray pictures that much of the oil dropped from the spray near the burner.

This burner was as currently used on the Florida East Coast Ry. The oil issues from a central tube surrounded by a number of atomizing steam jets aligned to produce the conical spray and rotational effect noticeable in the photographs above. Note the generally uniform entrainment of oil around periphery of spray, even at low rates when oil might predominate in lowest jets except for rotational action distributing the oil uniformly. Because of the short bushy jet, the spray patterns at distance taken are of little value and, primarily, merely confirm an expected absence of heavy concentration along burner axis, but do show spray cone was not hollow. Atomization shown, was not necessarily best possible, pressures being low as compared with those used during engine test.

CLARK BURNER

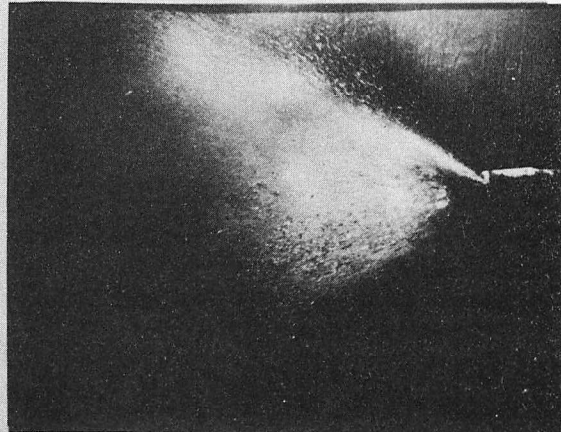


**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE

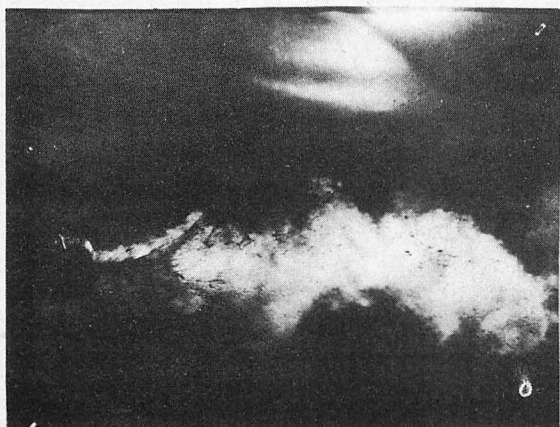


GYROJET BURNER

This burner has a central oil passage, with outlet one and one quarter inch inside the burner, surrounded by steam jets having a tangential component and aligned to sweep outer end of the 1-1/4" long mixing chamber. Note uniform dispersion of oil around spray, particularly at low rate; also that spray cone starts full from burner mouth. Note too, at both rates the absence of heavy, large particles in the portion of outer spray visible. The wide angle of spray together with absence of any directly axial jets precluded obtaining spray patterns at the usual distance of eight feet and the spaces above are therefore shown blank. To compensate for this short wide flame shape in the engine application, the burner to flash wall distance was reduced and trough of pan flared. For best results in service at high rates burners of this style required atomizing steam pressures 25% to 50% greater than those used in cold tests, so atomization illustrated is possibly not the best obtainable at the high rate with this burner.

**OIL SPRAY
PATTERNS
OBTAINED
AT DISTANCE
OF EIGHT FEET
FROM
BURNER**

LOW OIL RATE



HIGH OIL RATE

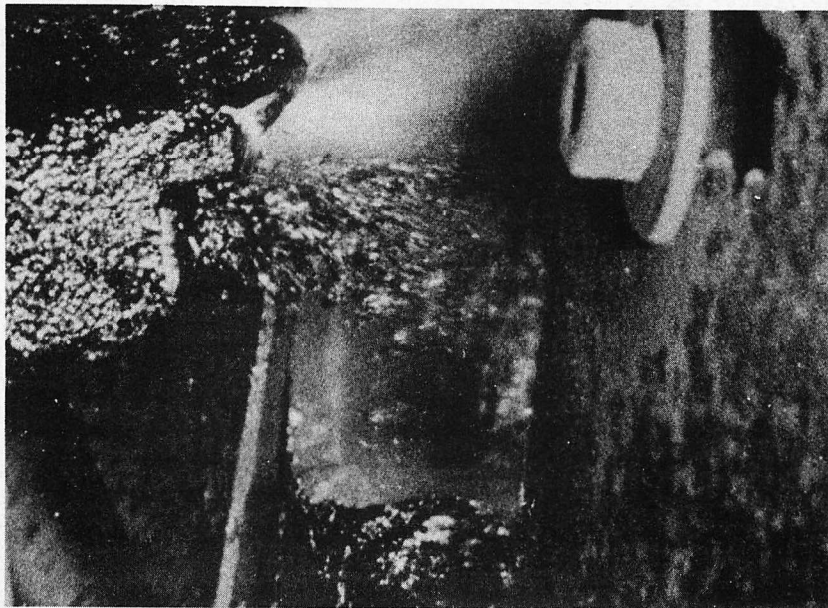
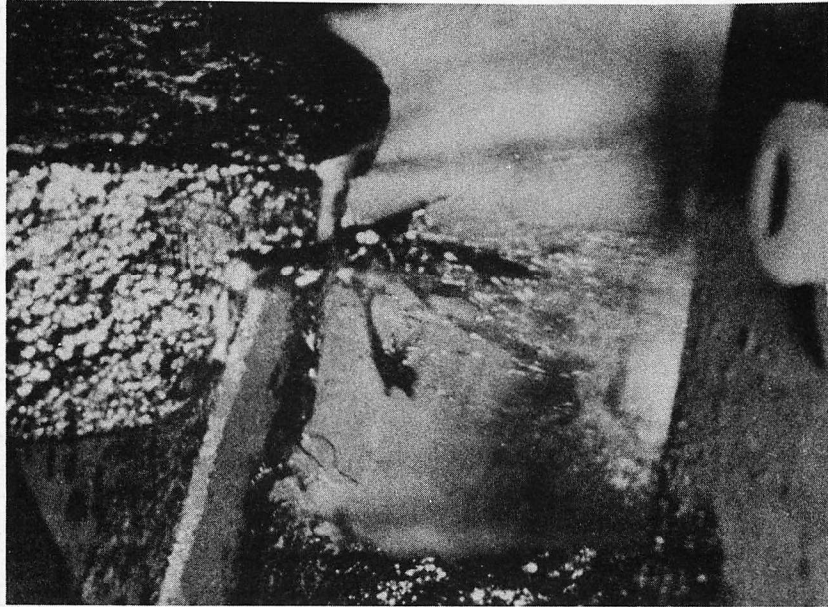


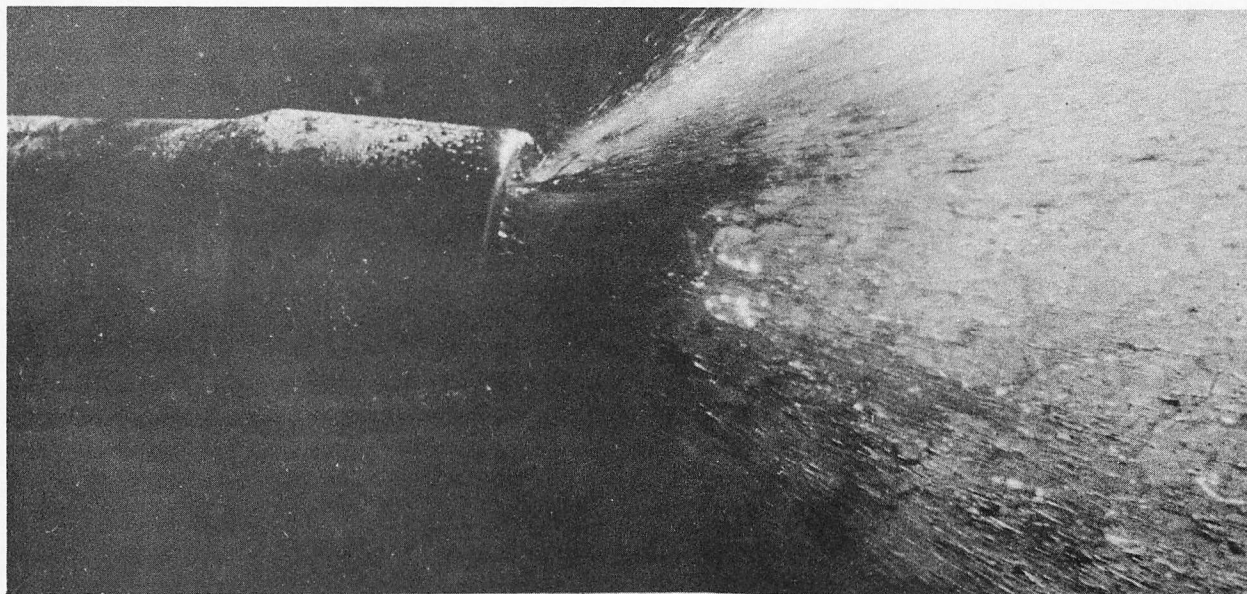
TUBULAR, CHAMBER TYPE, BURNER

This burner had an inner mixing chamber the length of which could be varied readily by moving the atomizing steam head in or out of the burner. The atomizing nozzles were drilled at an angle to radiate conically and impart a whirl to the oil in the chamber. The oil left the chamber, and the burner, through an orifice of smaller diameter than the chamber section. In the pictures of the spray it will be noted that the vapor cloud from the atomizing steam assumed an unusual shape which no doubt resulted from the strongly rotative direction of the internal jets. Under the lighting conditions existing, the oil spray outside the steam area is but faintly discernible but from the spray pattern it is evident that the spray was uniform and dispersed over a wide area. At the high rate, the lighting exposed the nature of the oil mass at the center of the jet but it will be noted that farther out in the spray the large masses break down and at spray pattern distance, the oil was uniformly distributed but contained some globules of quite large size.

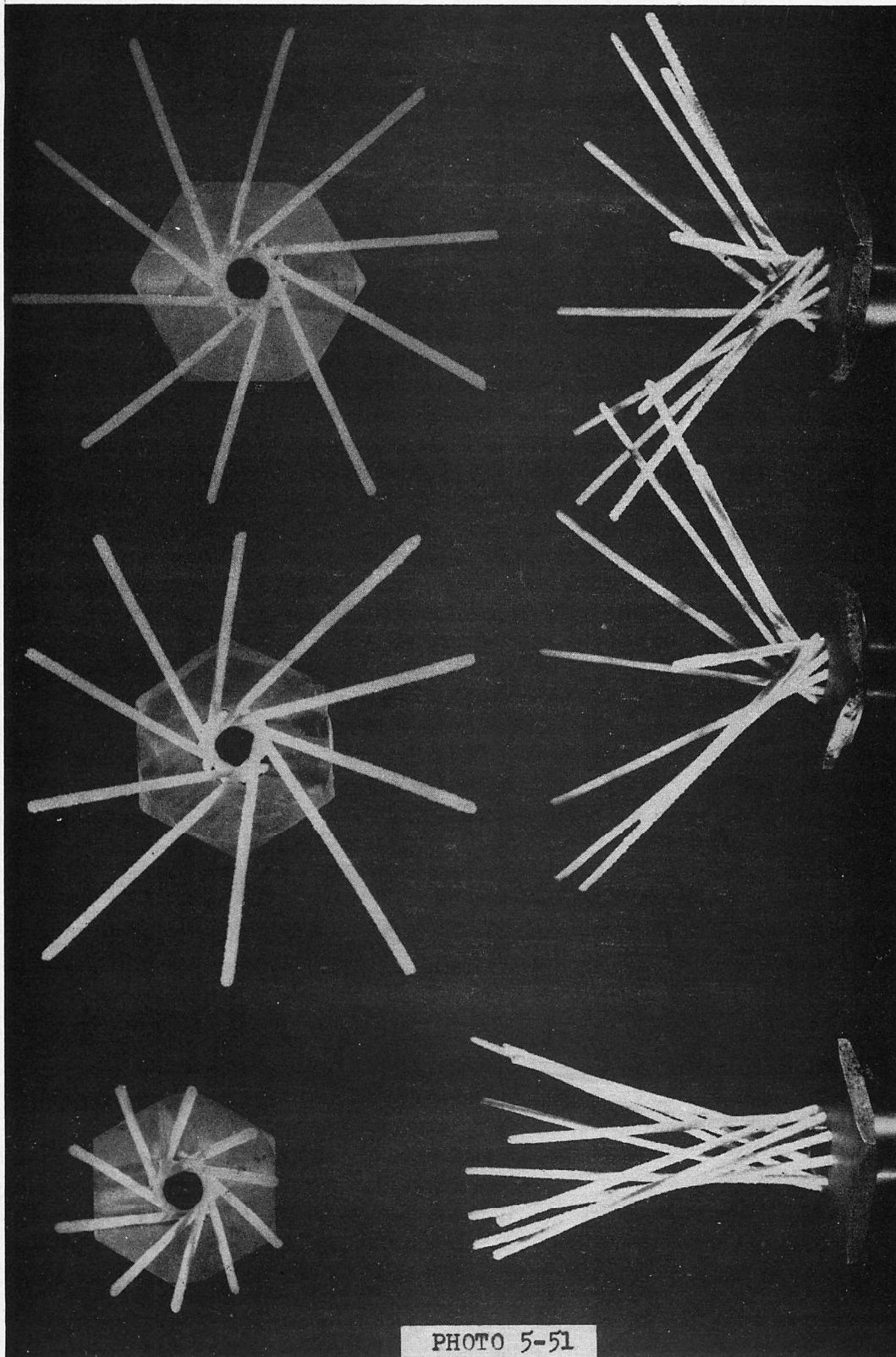
These photographs show the Von Boden burner in operation during ST-4 series of tests with the Dutch ovens. During these tests, burner tip was just outside burner port, as shown, to avoid excessive heat on burner. This permitted photographing the jet near tip, by high speed flash. Top picture shows burner operating with 40 PSIG atomizing steam at an oil rate of 7 GPM. Lower photograph shows performance at 8-1/2 GPM and 50 PSIG atomizer. These oil rates were both only about one-half the maximum yet the poor atomization illustrated was very similar to "cold test" results at high flows and in that connection, note oil accumulation above burner port from high flying spray.

VON BODEN BURNER IN OPERATION





Comparison of oil spray at outlet from Clark and Gyrojet types of burners, illustrating heavy oil froth formed around jet close to tip of Clark type, upper burner, at high oil rates, causing heavy particles in outer fringe of spray. Extended mixing chamber of Gyrojet type, lower burner, prevents seepage of oil from between jets, and in combination with action of jets in sweeping chamber edge, provides fine mist in outer fringe for first contact with primary combustion air entering axially through burner port.

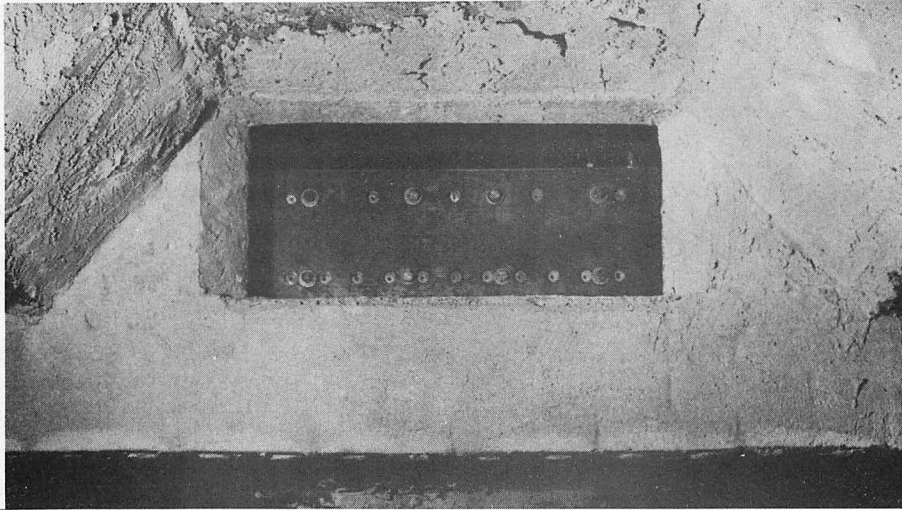


MODELS ILLUSTRATING DIFFERENT ANGLES OF ATOMIZING JETS FOR GYROJET TYPE OIL BURNERS

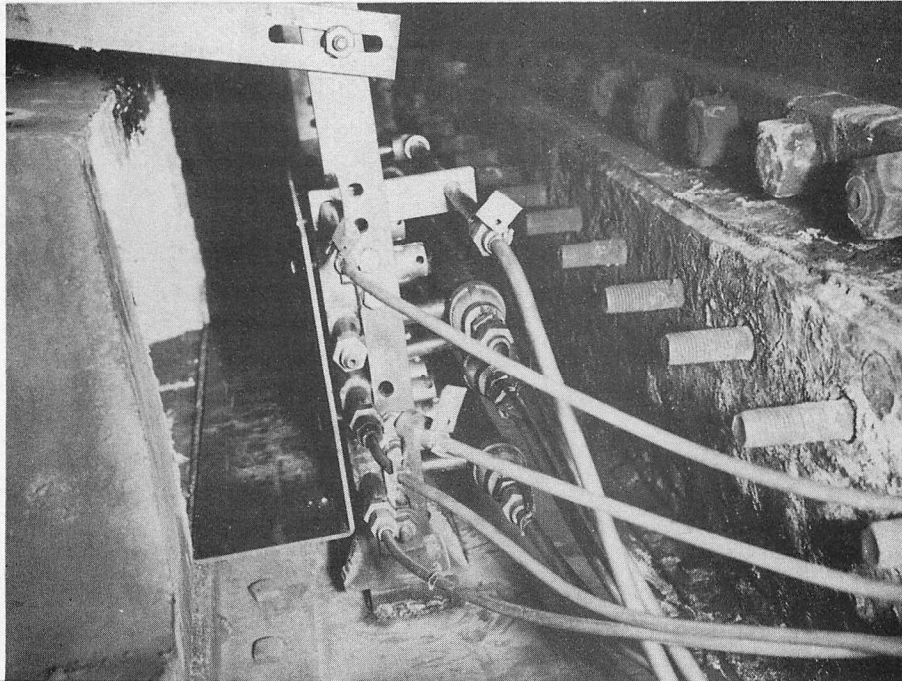
On left is model with jet at angle of 16° when viewed diametrically across burner. It is most evident on this narrow angle model that the axes of the jets do not intersect at any point but all are tangent to a cylinder approximately the diameter of the oil outlet. This tangential component of the jets imparts a gyratory motion to the spray and flame, and disperses the oil conically and uniformly, even for very small oil flows. With the 16° angle, the spray was too concentrated. Burner B-11 had the 30° angle of the center model, and burners B-12 and B-13 a slightly greater angle than the 39° model at right.

PHOTO NO. 5-51

View of Coen 16-Burner assembly and airport from inside firebox, showing arrangement of the 16 burners; eleven in upper row and five in lower, the center burner of lower row being for use as pilot. Alternate burners in upper row were piped separately to form two burner groups, one of six and another of five. The four outer burners of lower row formed a third group. Beginning with pilot burner, additional burner groups were brought into operation in succession as necessary to obtain oil rate desired.



Exterior view of Coen 16-Burner assembly mounted on front end of firepan trough showing L-shaped mounting plate positioned to prevent entry of air from above burners; the adjustable bracket, and the connections, left, for oil and right, for the atomizing steam.



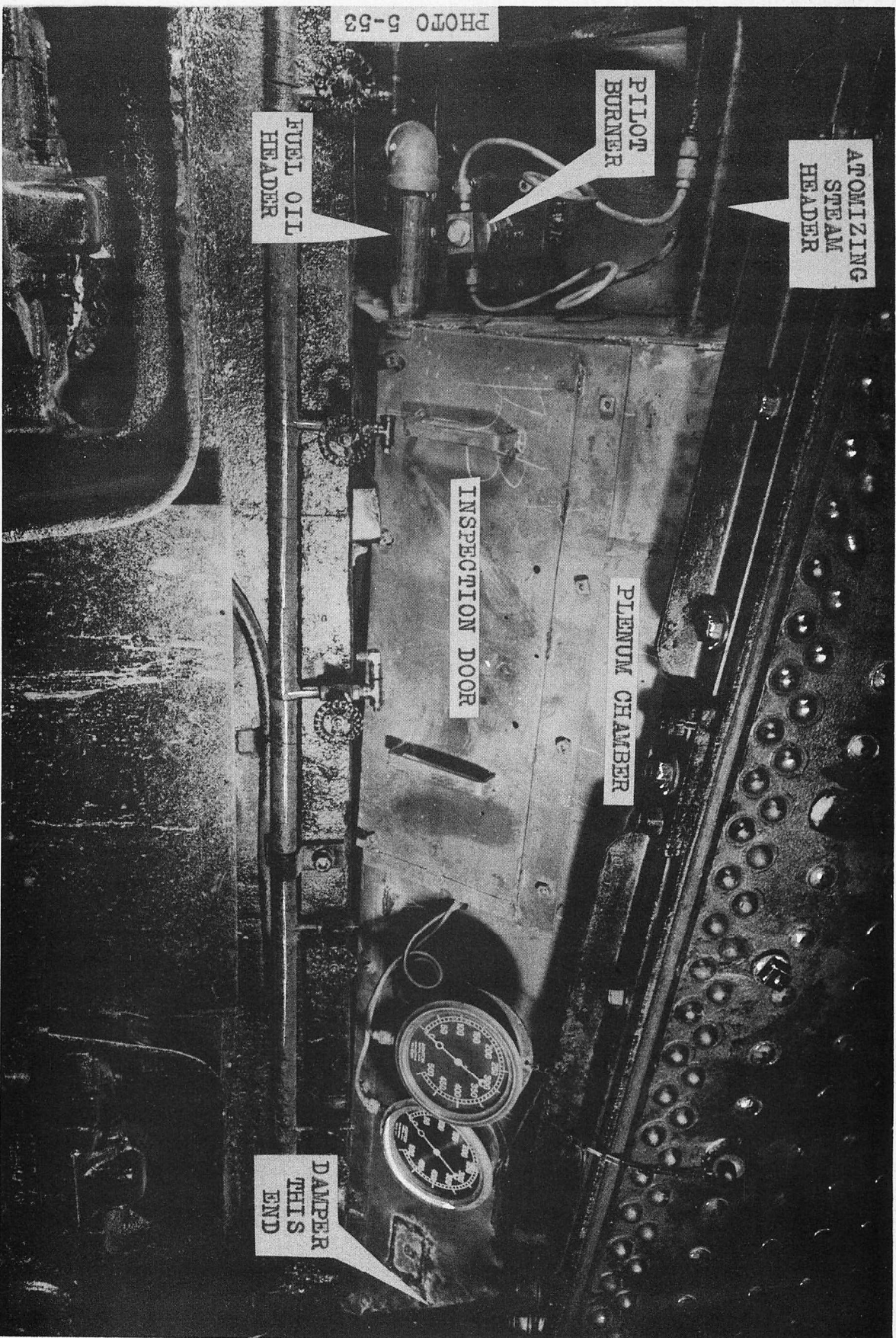


PHOTO 5-53

Exterior of Coen side burner installation on test locomotive showing general arrangement and the plenum type firepan enclosure, housing main burner portion to permit combustion air control and yet maintain uniformity of air distribution to airports and burners. Note large headers used for main steam and oil lines to eliminate velocity effects from these distribution systems. Pilot burner piping was separate, as shown.

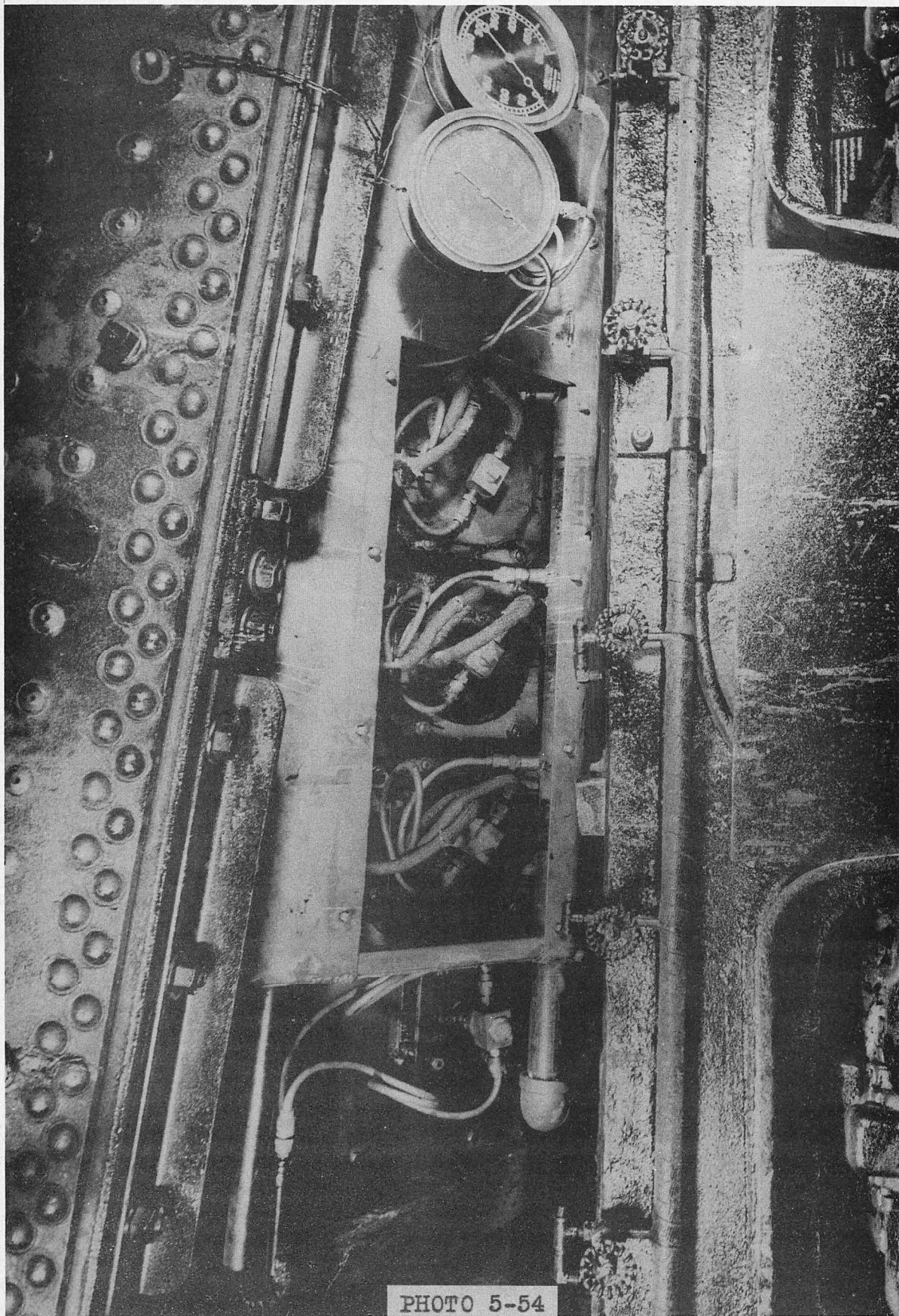


PHOTO 5-54

Exterior of Coen side burner installation with inspection door removed to show the three main burner assemblies as applied on each side of the firepan, in addition to the pilot burners. Gages shown, were connected to fuel and steam headers merely for information.

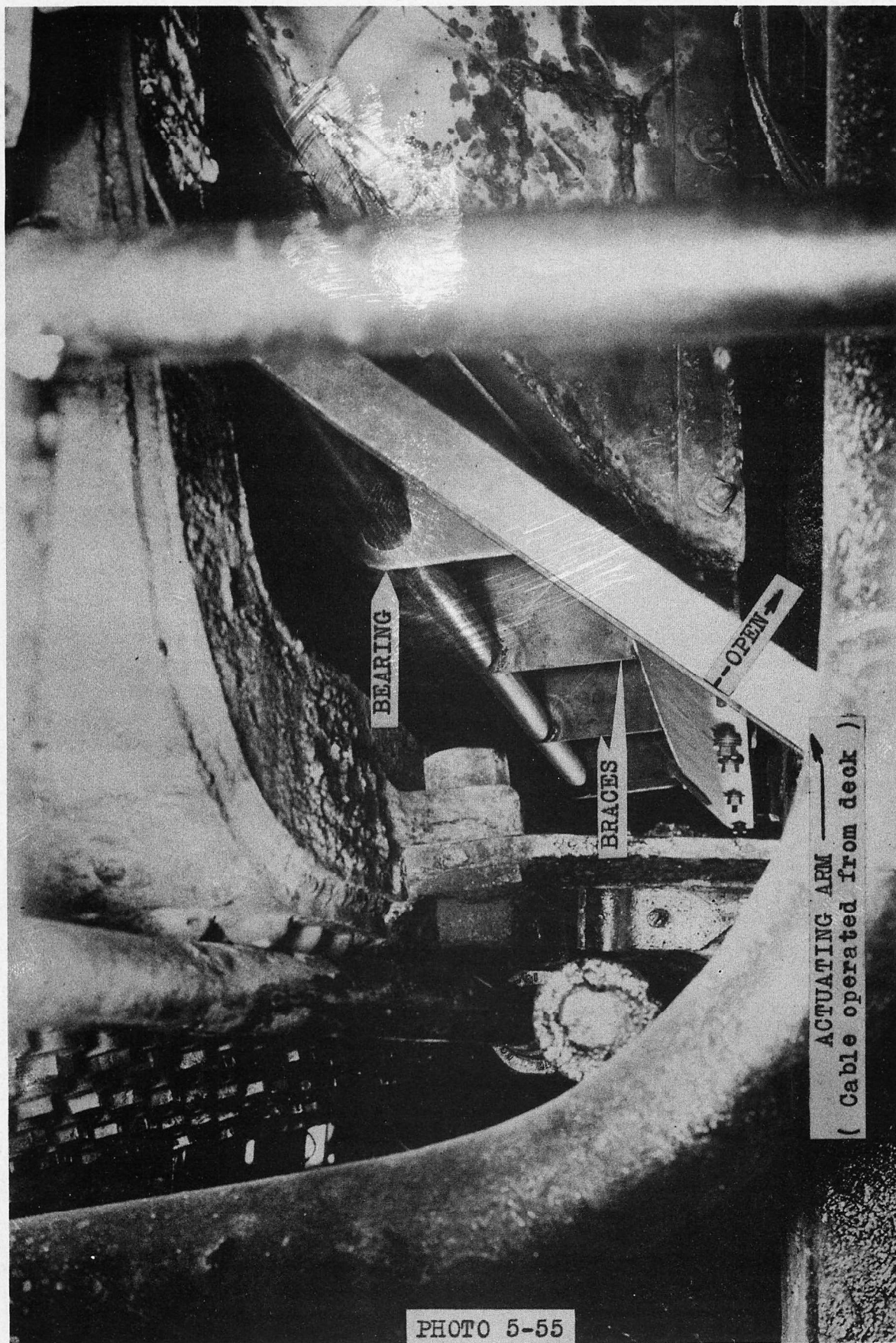


PHOTO 5-55

Coen side burner installation showing quarter-round, semi-cylindrical damper installed in 10" wide, 5 foot long air opening in front end of the plenum chamber housing portion of firepan containing main burners and airports. Damper shown closed.

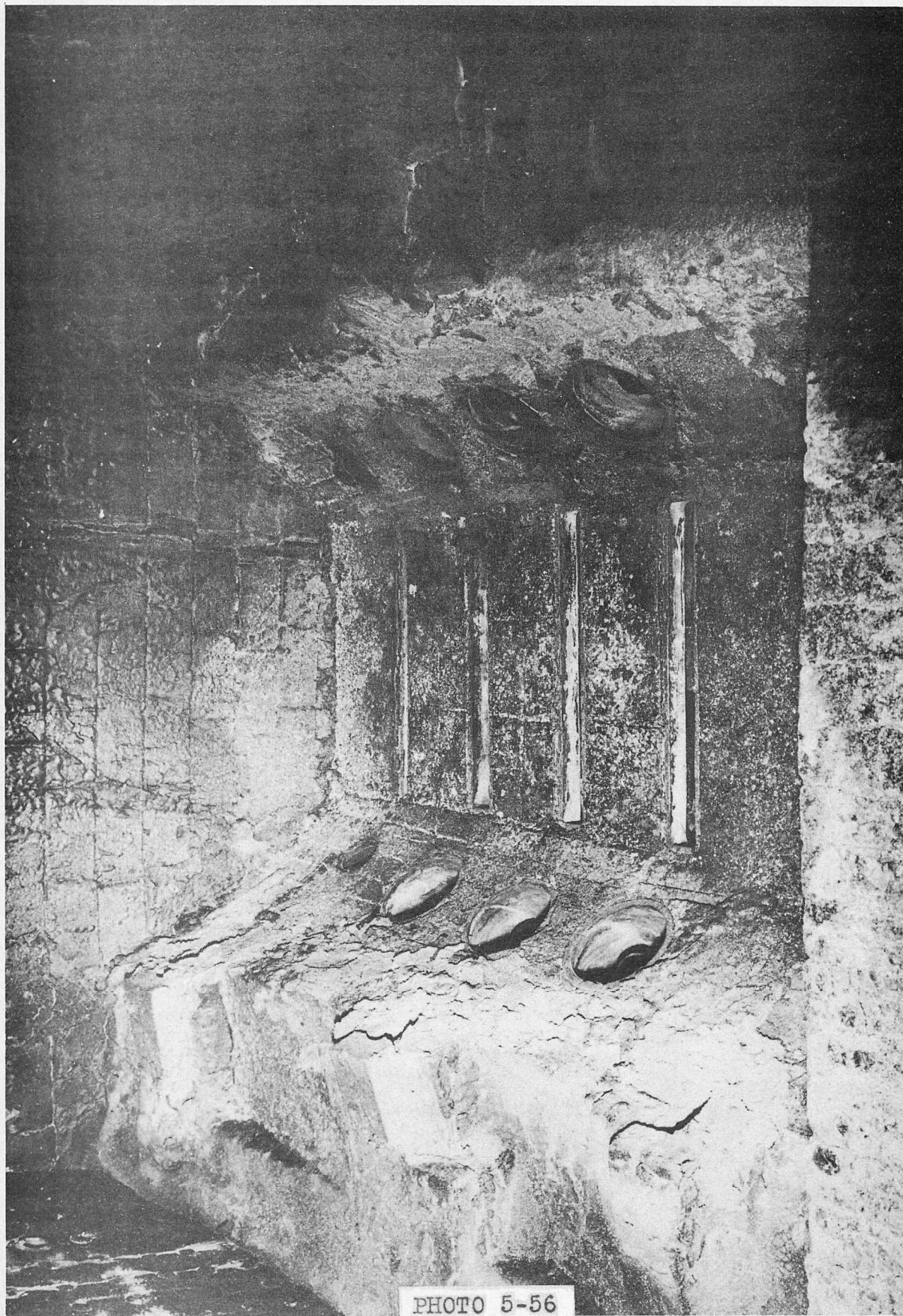
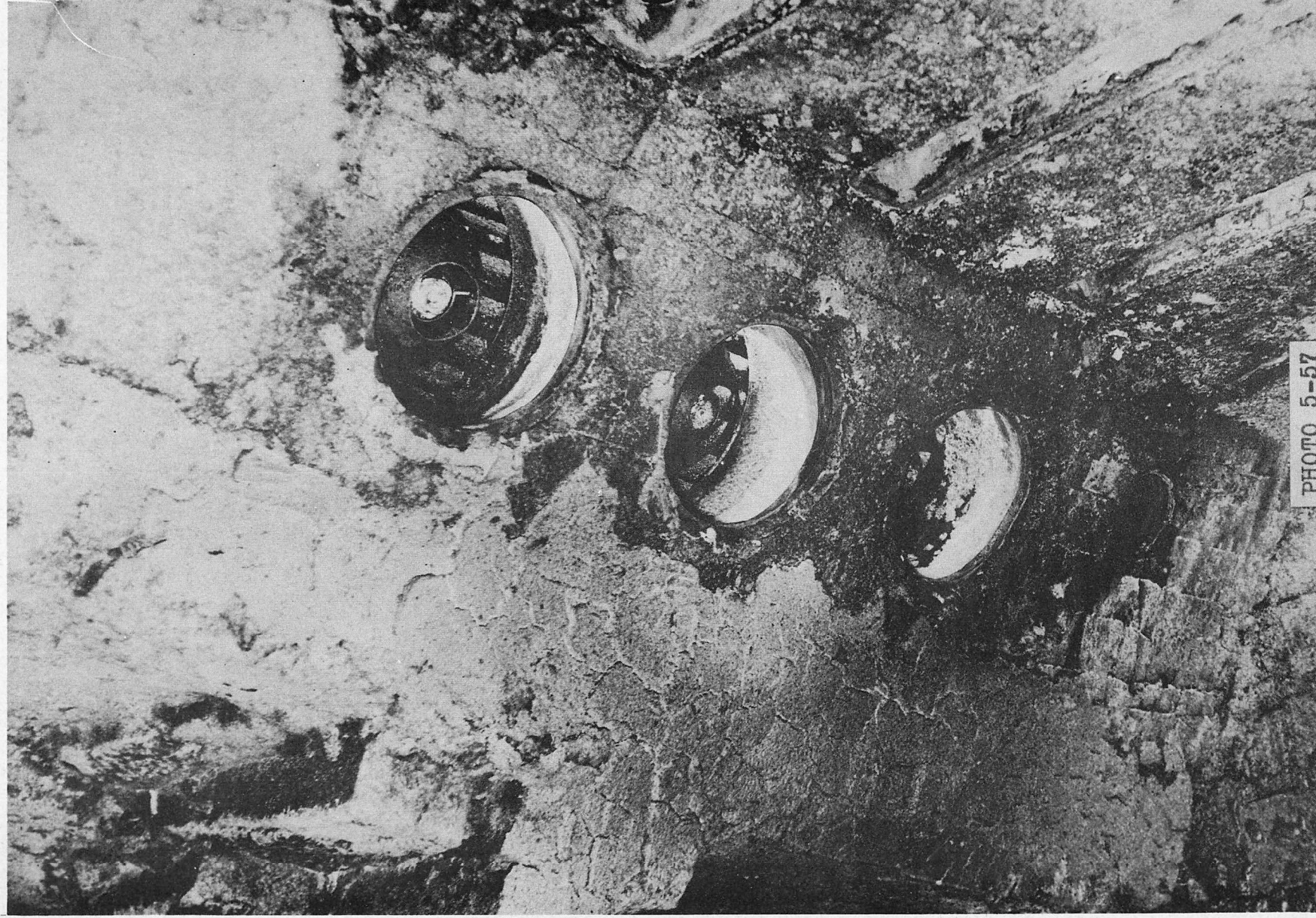


PHOTO 5-56

Coen side burner installation in T&NO style firepan, as viewed from tube sheet end, showing the three large ports each side for main burners, and in floor, the 2-3/4" x 28" main ports for secondary air for each pair. In background at firedoor end, the smaller ports for pilot burners are visible together with the small 3/4" x 28" port for secondary air for that pair of burners.

Coen burners installed in side trough sheet of T&NO style firepan, as viewed from firebox, showing burner with conical air diffuser attached, and through some ports, a portion of the vanes by which entering air was given a rotation. Design of port casting was such that even with diffusers, the minimum area for flow was fixed by inner diameter.



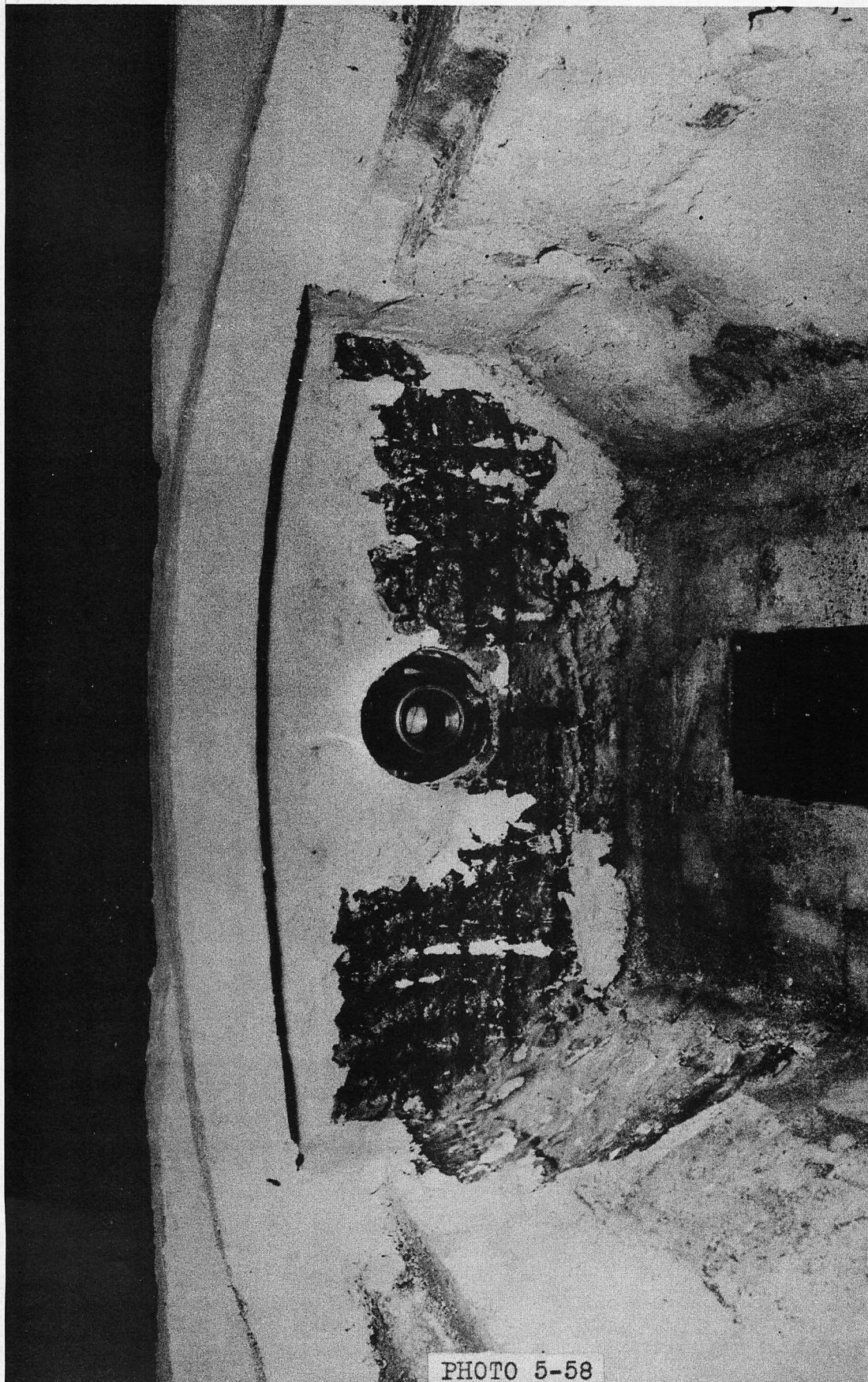


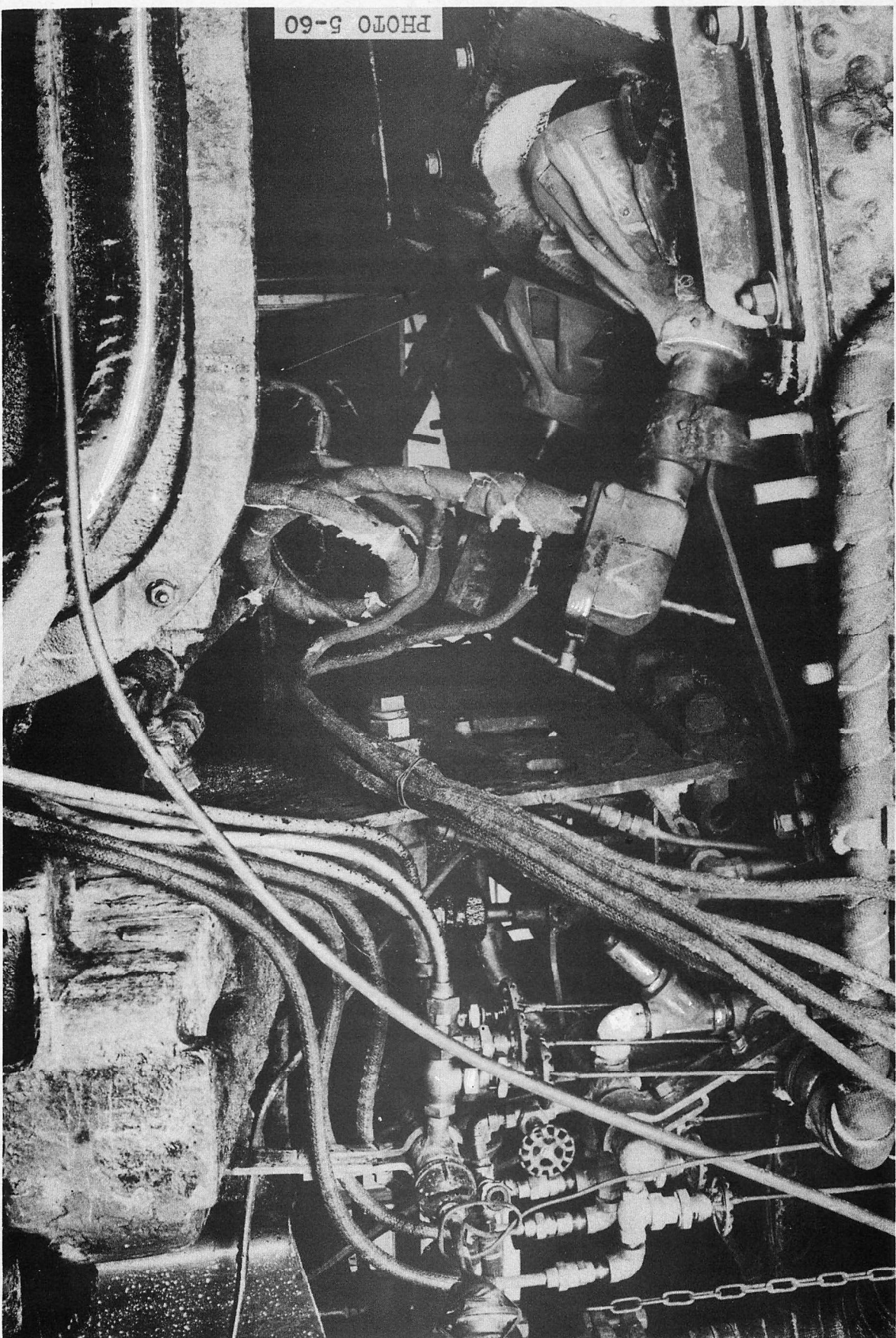
PHOTO 5-58

Original installation of Alexander rotary cup type burner as viewed from interior of firebox, showing 8" diameter burner port in front end of T&NO style firepan and arch extending 9" out over burner; also portion of 9" wide by 24" long bottom airport starting 12" from burner wall. Additional bottom airport, not shown, was located 9" from flash wall. Air velocity and direction proved unsatisfactory with these openings and several changes were made to avoid lifting of fire. Note air bypass possible between burner and side walls.

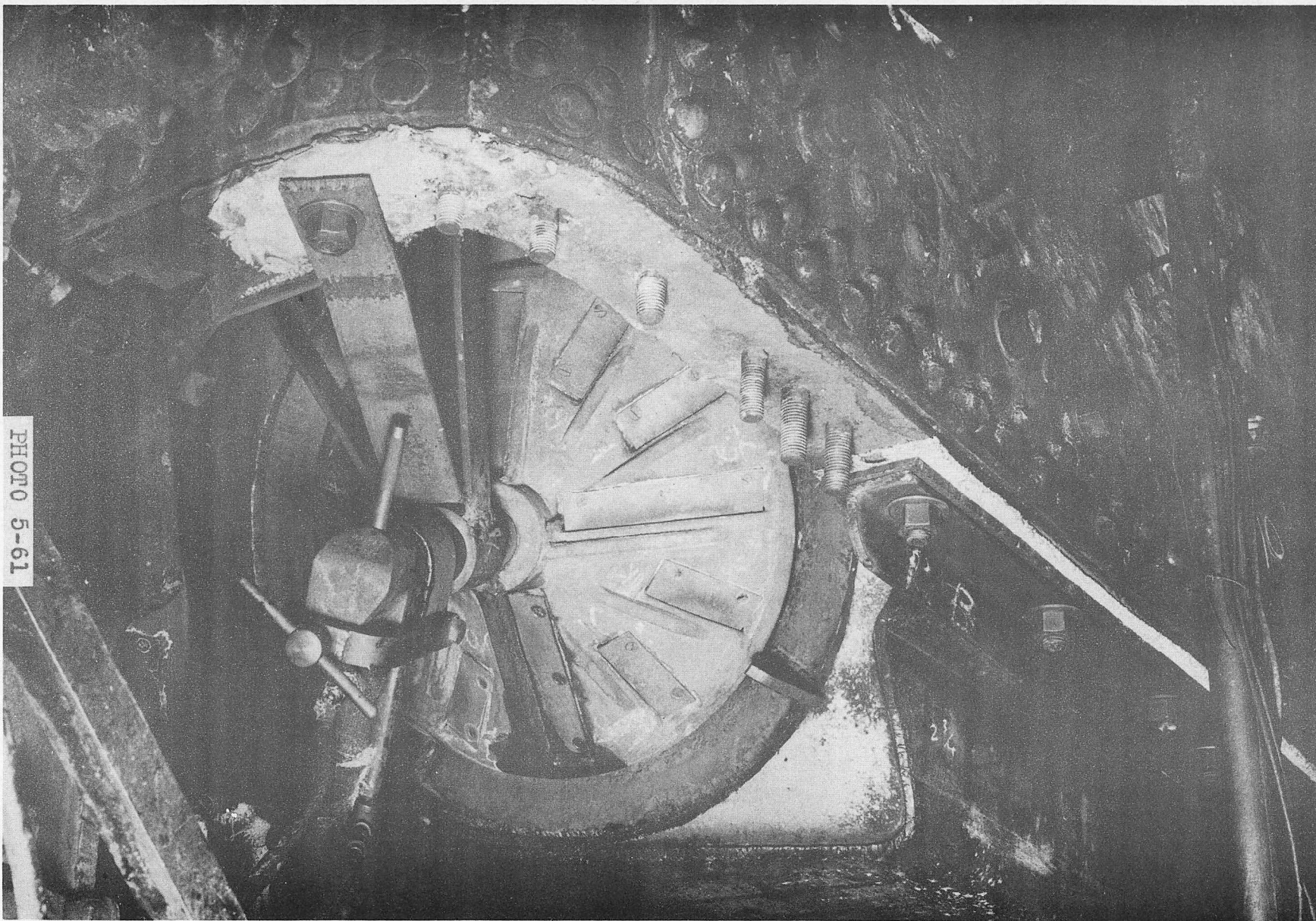


PHOTO 5-59

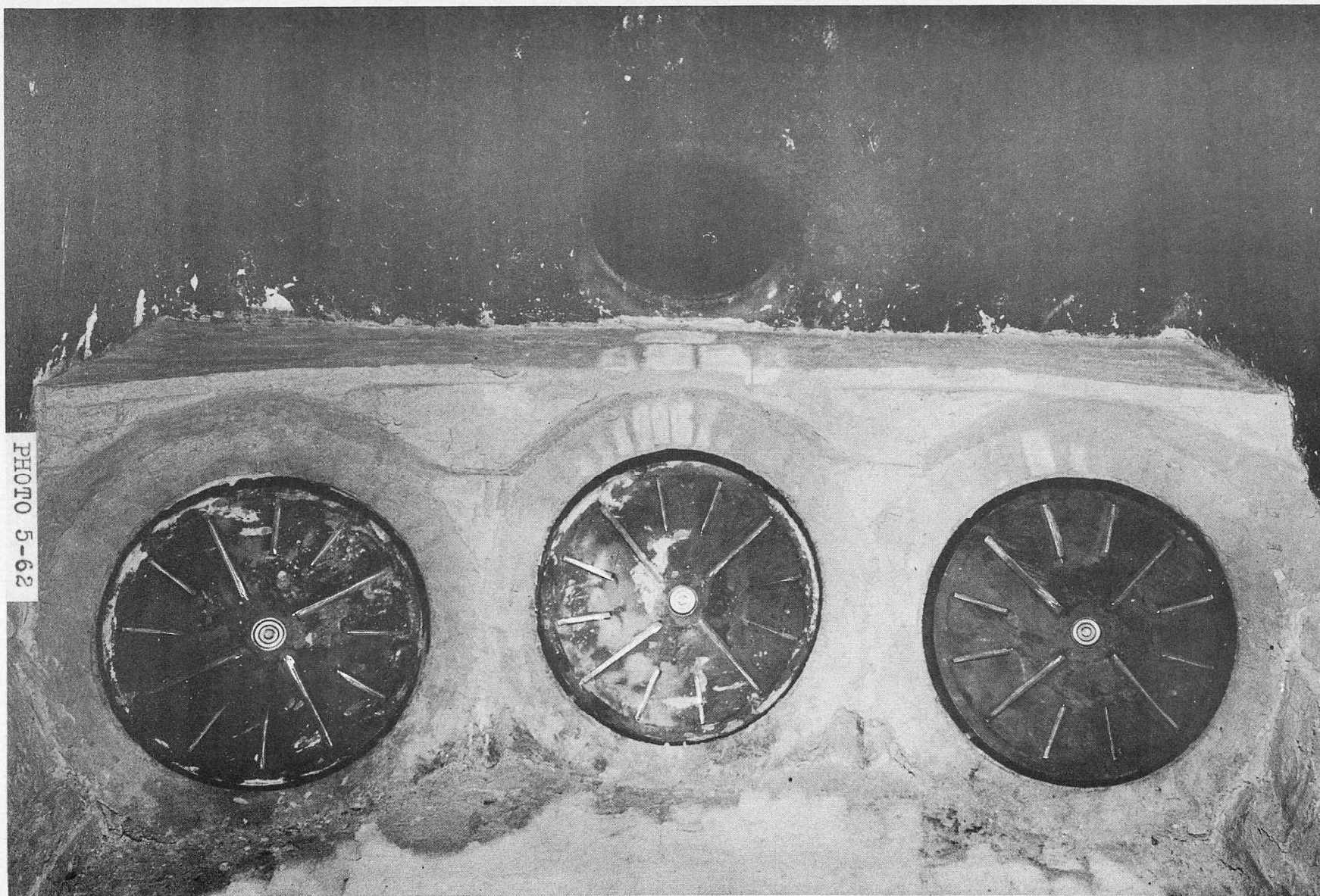
Alexander rotary cup type burner installation, with wing walls in addition to 9" arch over burner to increase radiant heat on oil spray near burner and confine the under-burner secondary air to the flame path. The hopper for the partly visible 12" wide, 24" long forward bottom airport had a brick covered bottom inclined toward flash wall and continuous with the firepan floor at the flash wall end. The hopper for the 18" x 19" rear bottom airport, not visible, was similarly arranged. The deflection of bottom air toward the flashwall by these inclines in hoppers, together with the use of horizontal port under the burner, eliminated strong upward currents from the entering air and the consequent turning of the light, finely atomized spray from its normal course the full length of firepan.



View of rear of special firepan showing application of three Nagel burners in NOEP shields, with connecting piping, and at right, the three, conical seat, oil control valves, with the three atomizer control valves slightly above them and to the right; all having extension handles passing up through cab floor to fireman's position. Annulus for secondary air could be changed by sliding assembly in or out in mounting bracket, the shield being free to move on guides visible.

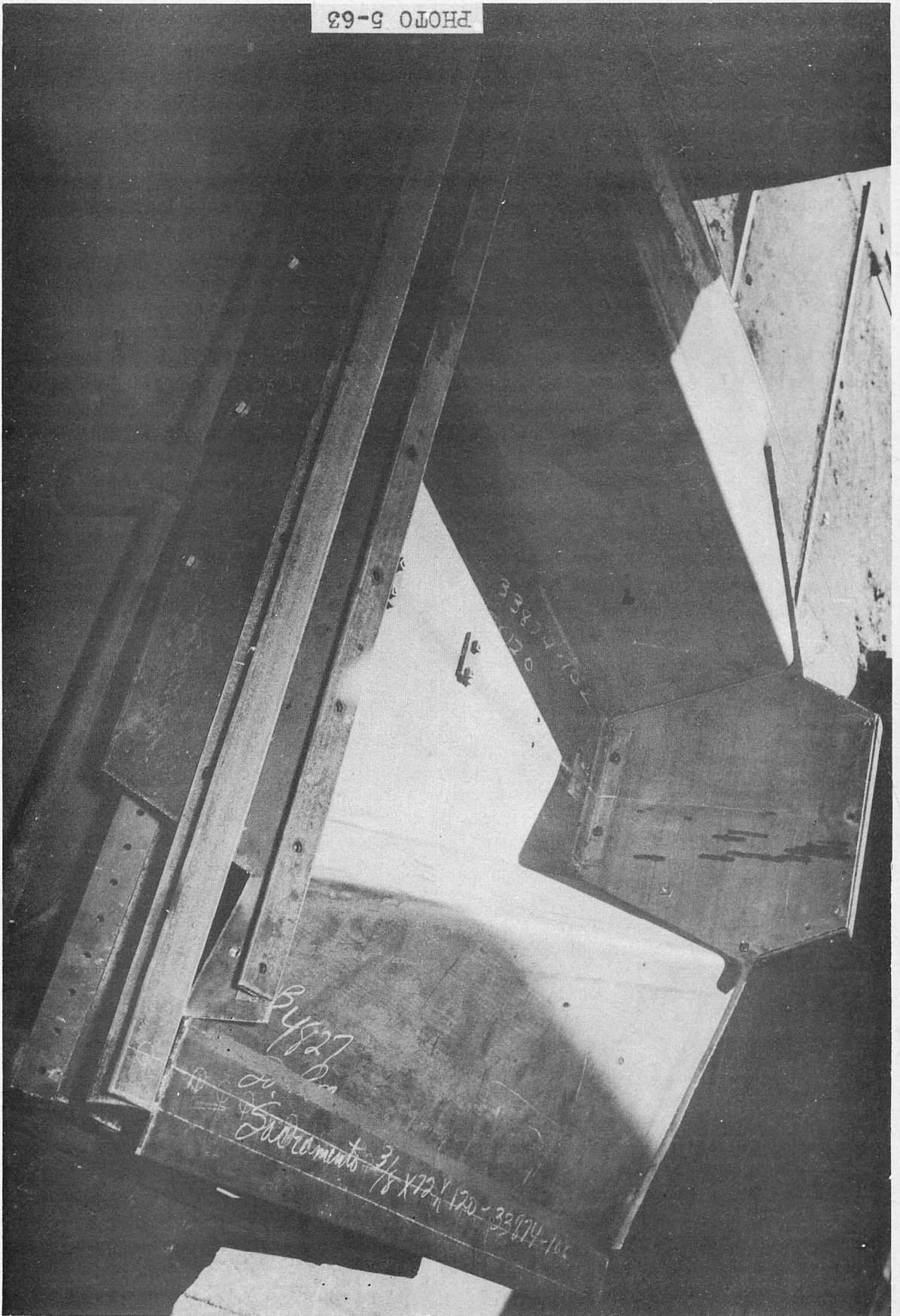


Exterior view of one of the three Nagel burners mounted at rear of special flat bottom firepan showing detail of 24" diameter, cast iron NOEP (Nagel Oil Economizer Process) shield with special metal louver blade inserts at primary air inlets designed to initiate and maintain combustion within the shield and assure turbulence through the rotational direction of the entering air.



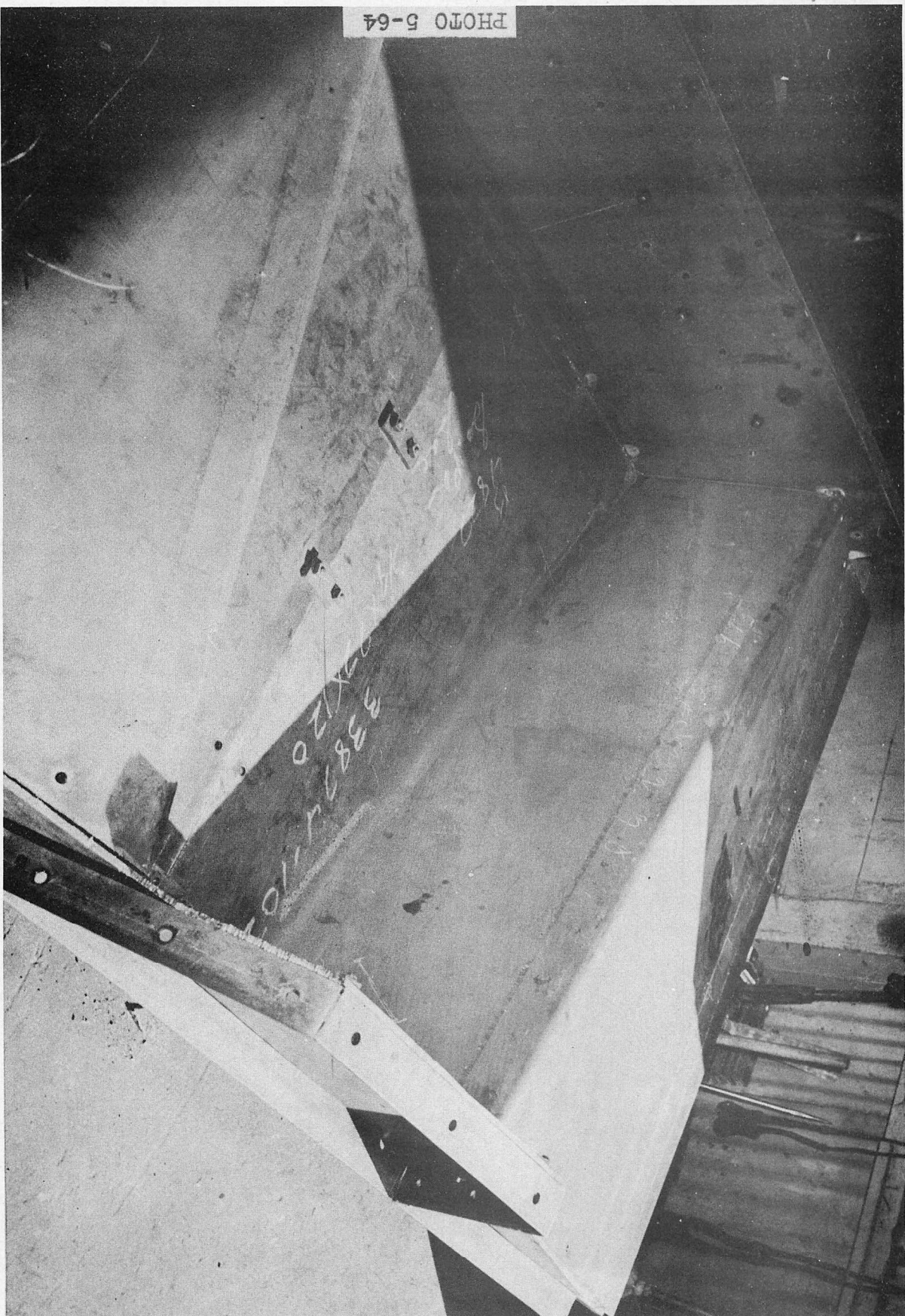
View from inside the firebox of three Nagel burners mounted in NOEP shields at rear of special firepan. This view was taken before a 1" wide air port was cut across entire width of floor just ahead of burner ports, to amplify supply in an area found deficient. All burners were directed up 30° from plane of firepan floor and outer two were in addition, aligned inward so axes intersected at 45° on center line.

PHOTO 5-63

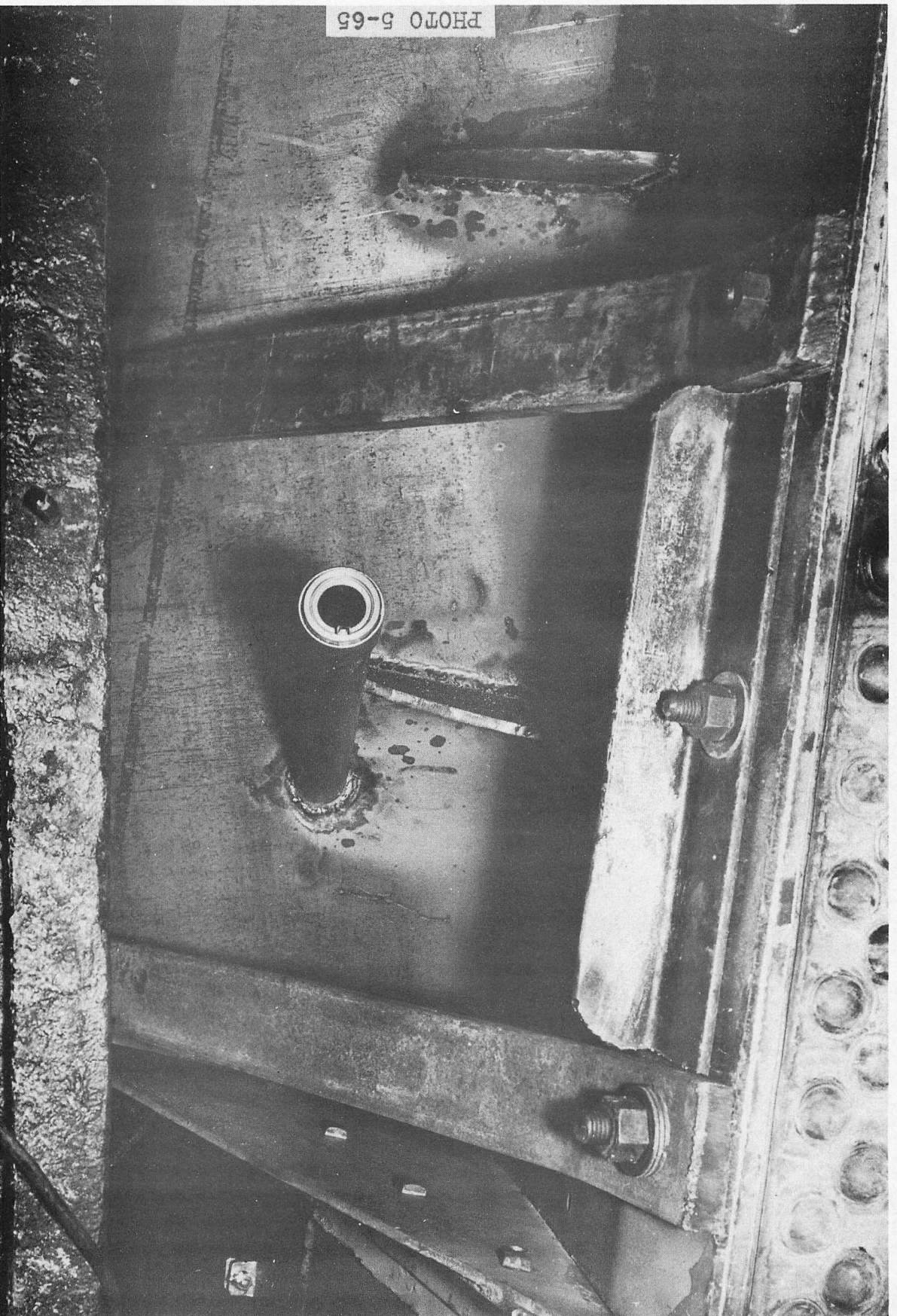


Trough of taper type firepan during construction, looking toward burner wall at rear. Flashwall sheet was later revised by trimming flush with top of main support angle shown. Side table plates were then flanged down to close small triangular space visible. Note layout of holes for mudding rivets along right edge. Burner wall shown, was cut away at sides to clear Security Circulators.

PHOTO 5-64

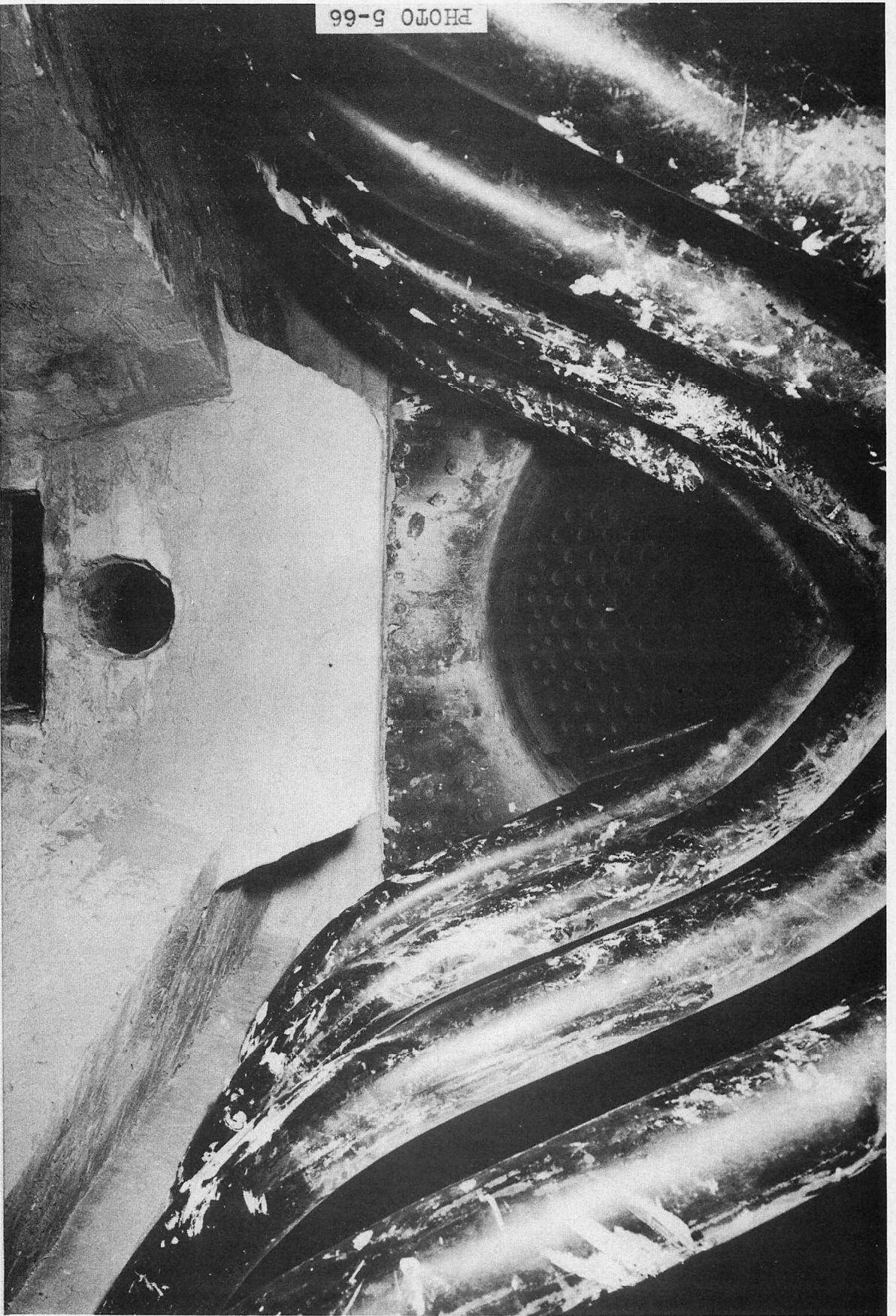


Trough of taper type firepan during fabrication as viewed from front corner. Construction shown at burner wall, right, was necessary to clear Security Circulators in test locomotive. The short trough with wide flare and high sides was designed to fit closely the flame from the gyrojet burner and hence assure good return of radiant energy from refractory to spray.



Exterior view of taper firepan near front showing two of the three 1" x 4" hanger type transverse supports and two of the gusset braces for side table plates. Tube, at center, permitted observation of conditions near burner tip during standing tests.

PHOTO 5-66



View of taper type fireman through firedoor of test engine while equipped with Security Circulators. Burner wall was cut away at sides to clear one of the circulators. Note height of wall above burner port to reduce short-circuiting to flues, and restriction of volume near burner by reduction in width of trough, which also assured a high degree of radiance on spray near start to assist in initial combustion.

PHOTO 5-67



Taper type firepan as viewed toward flash wall, showing bottom airport. Slope of rear edge of port as shown, was later eliminated account plate burning out and all edges were made to slope inwardly. For service, a grey iron casting would be used.

PHOTO 5-68

Gyrojet burner viewed through burner port of taper type firepan as applied to test engine while equipped with Security Circulators. Note bottom edge of port under burner was raised above floor to trap any spilled oil. Burner port shown was venturi shaped to assure full flow and flare at inner end directed any drip page from burner into firepan.

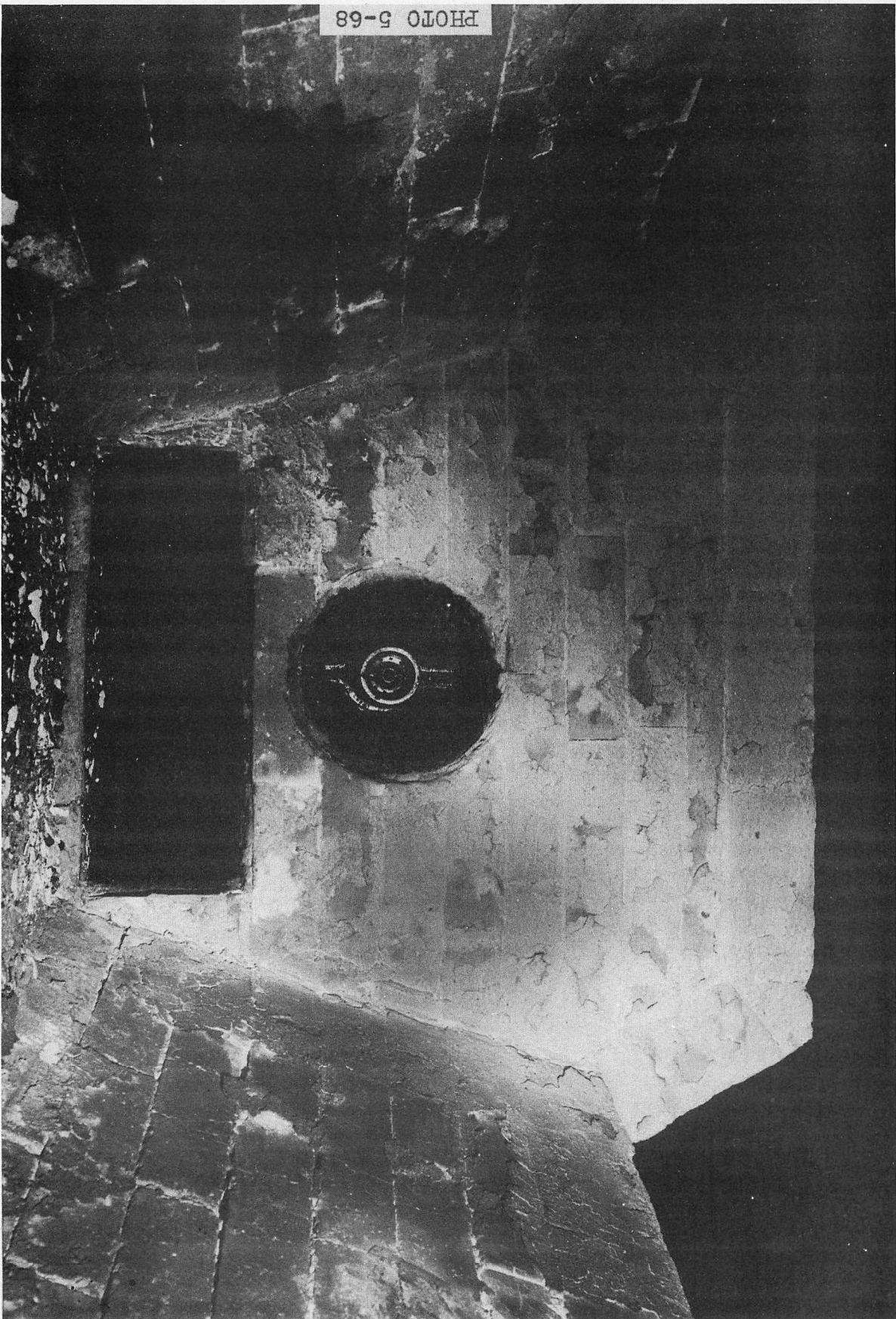
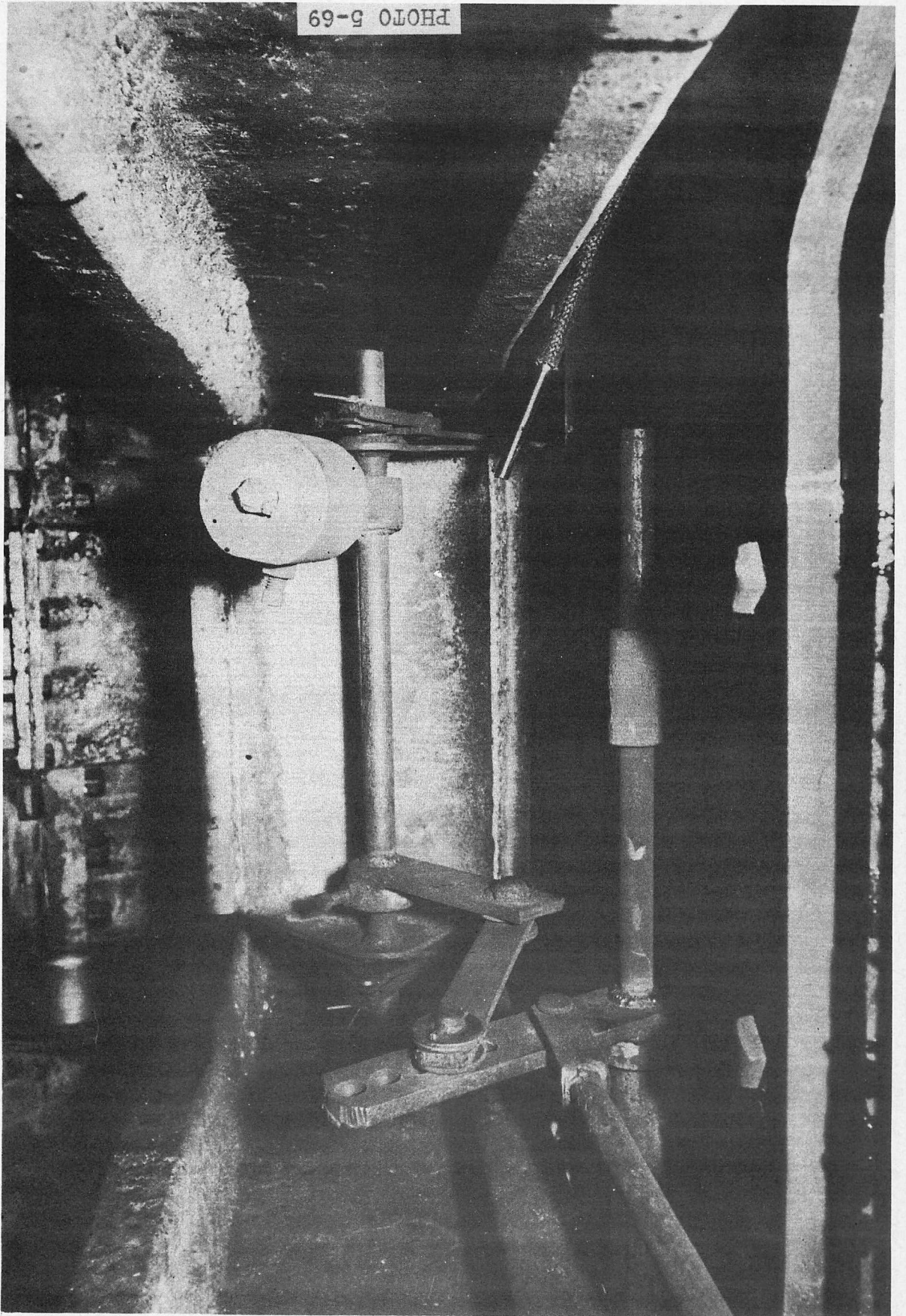


PHOTO 5-69



Semi-cylindrical type damper on bottom hopper of taper firepan, shown in closed position. Rod at top extended out beyond bottom of pan and was connected with cab lever. Top clevis on arm was connected to butterfly damper on hopper under burner. Note rounded edges on damper to promote flow.

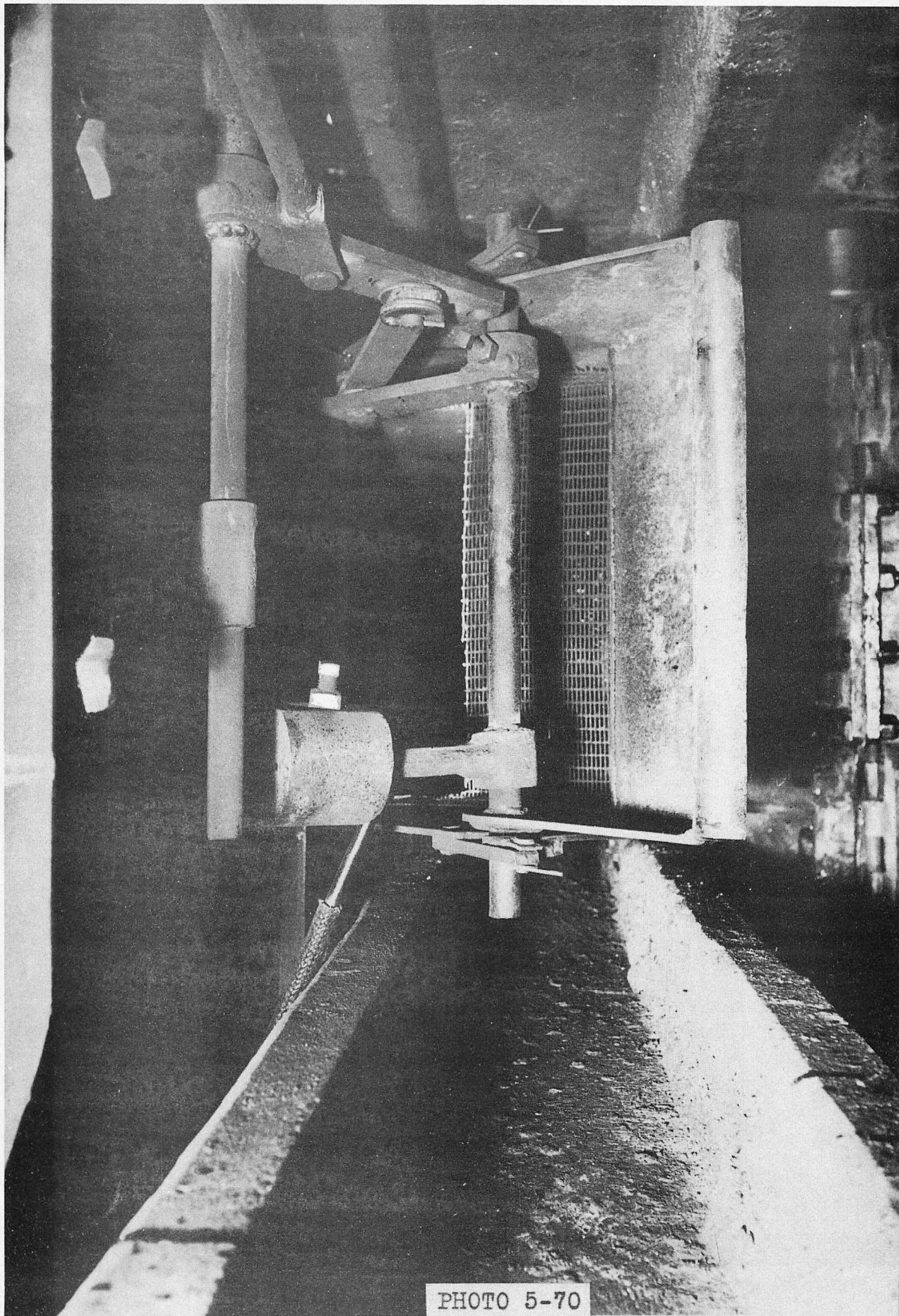
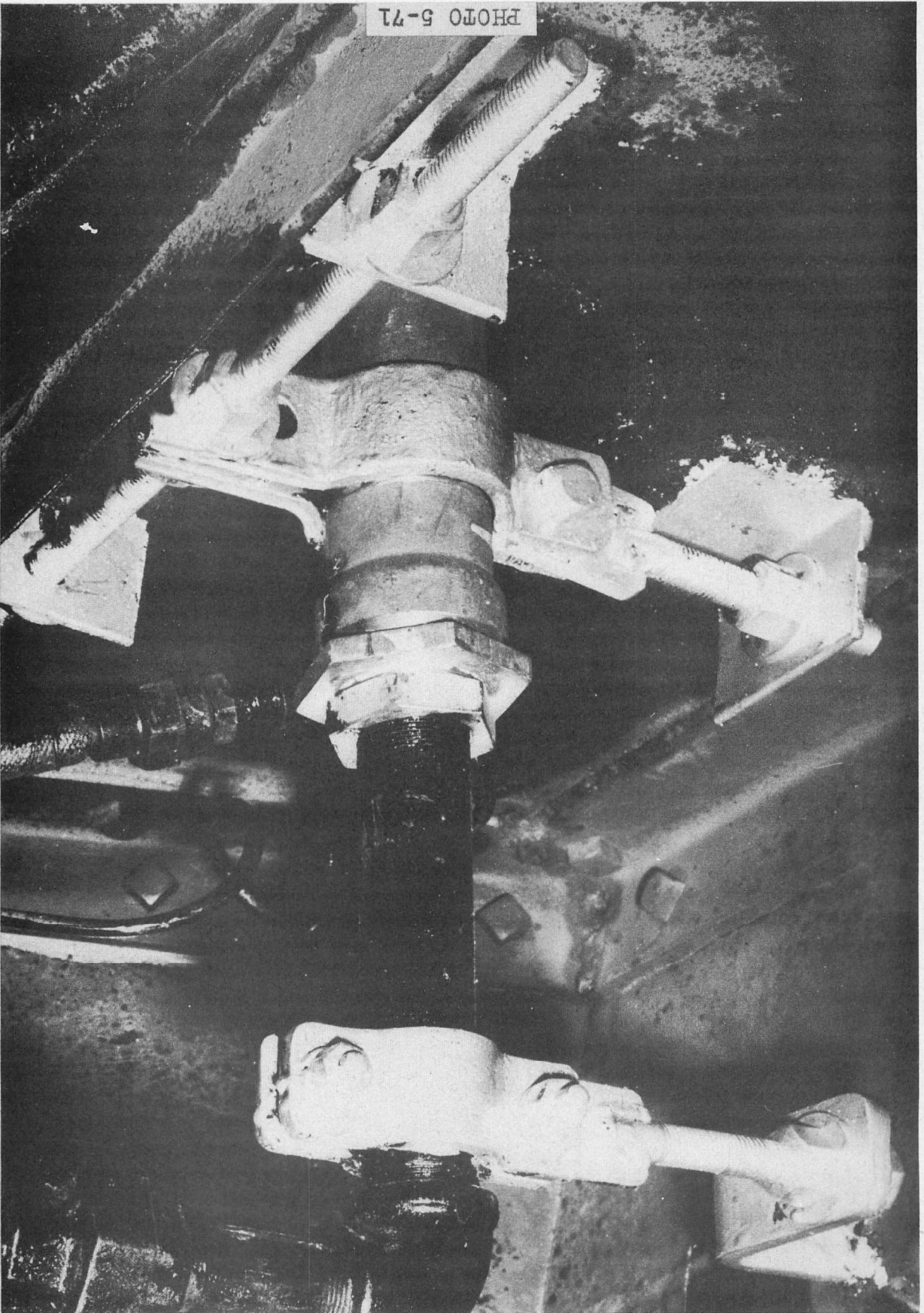


PHOTO 5-70

Semi-cylindrical type damper on front end of bottom hopper of taper firepan, shown in open position with screen for preventing escape of combustible material visible. Entire damper was readily removable by means of latch arrangement shown with cotters in pins at each damper bearing. For service, all lever connections were changed to a clevis type.



Gyrojet burner installation on engine during tests, showing adjustable type bracket used to allow changes to burner position during operation.

SUMMARY OF DATA																							
TEST ARRANGEMENT	TEST DESIG- NATION	EXHAUST NOZZLE PRESSURE PSIG	FIRING RATE		TEMPERATURES DEGREES FAHRENHEIT			DRAFTS INCHES, WATER			WATER RATES 1000 LBS. PER HOUR		STEAM RATES 1000 LBS. PER HOUR		BOILER EFFICIENCIES-%		FLUE GAS COMPOSITION - %			AIR FLOW FROM FLUE GAS ANALYSIS			
			1000 LBS PER HOUR	B.T.U. PER HOUR IN MILLIONS	EXHAUST STEAM	SUPER- HEATED STEAM	FLUE GAS	INSIDE ARRESTER	BEHIND ARRESTER	FIREBOX	WATER FROM TENDER	WATER TO BOILER	STEAM TO NOZZLE	EQUIV. EVAP. FROM AND AT 212°	EXCLUDING FEED WATER HEATER	INCLUDING FEED WATER HEATER	CARBON DIOXIDE	OXYGEN	CARBON MONOXIDE	LBS. AIR PER LB. OF OIL	LBS. AIR PER HOUR IN THOUSANDS	PERCENT EXCESS AIR	
GREAT NORTHERN BURNER-14" ABOVE BRICK, 3/4" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, BURNER PORT-8" DIA., BOTTOM OPENINGS-35T-29T RINGS, SIDE OPENINGS-24 2" I.D. FLUES RIGHT AND LEFT.	B3-T4-AD	9.7	6.41	116.6	309	670	615	18.2	18.0	10.8	67.7	79.4	66.3	95.0	79.0	90.6	13.6	3.0	0.0	16.5	105.8	15.9	
		7.2	5.34	97.3	303	650	590	14.5	14.4	8.8	58.8	69.2	57.5	82.6	82.4	93.9	—	—	—	—	—	—	
		4.8	4.33	78.8	291	639	570	10.2	10.1	6.1	48.4	56.3	47.1	67.4	82.9	93.8	12.4	4.7	0.0	18.1	78.3	27.5	
		2.2	2.88	52.5	284	589	529	5.6	5.6	3.6	33.8	38.6	32.7	45.5	84.2	94.7	12.4	4.7	0.0	18.1	52.1	27.5	
ROCK ISLAND BURNER-7" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, T.&N.O. BURNER PORT, BOTTOM OPENINGS-25T-29T RINGS, SIDE OPENINGS 40 2" I.D. FLUES RIGHT AND LEFT.	B4-T11-AB	12.6	6.21	112.9	316	661	612	17.8	17.5	8.8	65.7	76.5	64.4	91.1	78.3	89.8	12.1	5.1	0.0	18.5	115.0	30.6	
		7.9	5.05	91.7	303	652	582	13.4	13.2	6.9	53.3	61.8	52.0	73.5	77.7	88.5	11.0	6.5	0.0	20.3	102.3	42.8	
		5.6	4.04	73.4	293	628	557	9.7	9.6	5.1	44.2	50.8	43.0	60.5	80.0	90.5	10.4	7.3	0.0	21.4	86.4	50.9	
		3.3	3.16	57.4	286	600	532	6.3	6.2	3.3	34.7	39.6	33.6	47.0	79.4	88.0	10.0	7.8	0.0	22.2	70.2	58.5	
PACIFIC LINES BURNER (4 1/2" VON BODEN) 7" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, T.&N.O. BURNER PORT, BOTTOM OPENINGS-25T-29T RINGS, SIDE OPENINGS-40 2" I.D. FLUES, RIGHT & LEFT.	B5-T11-AB	12.7	6.36	115.5	318	678	612	18.3	18.1	9.9	66.4	77.5	65.0	93.0	78.1	89.3	12.4	4.6	0.0	18.0	114.7	26.7	
		8.3	5.05	91.6	301	652	582	13.7	13.5	7.4	53.2	60.8	52.0	72.7	77.0	87.5	11.5	5.7	0.0	19.4	97.6	35.5	
		5.6	4.06	73.8	293	628	561	9.6	9.5	4.9	44.2	50.1	43.0	59.7	78.5	88.7	10.8	6.8	0.0	20.6	83.8	45.8	
		3.3	3.06	55.5	286	596	528	6.1	6.0	3.2	33.7	38.9	32.6	46.0	80.3	90.1	10.2	7.6	0.0	21.8	66.7	54.3	
FLORIDA EAST COAST BURNER-7" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, T.&N.O. BURNER PORT, BOTTOM OPENINGS-25T-29T RINGS SIDE OPENINGS-40 2" I.D. FLUES RIGHT AND LEFT.	B6-T11-AB	12.3	6.22	112.9	319	669	602	18.4	18.1	9.7	65.8	77.2	64.5	92.3	79.3	90.8	12.1	5.0	0.0	18.5	114.8	29.7	
		8.1	4.99	90.5	301	650	579	13.9	13.7	7.4	53.0	61.9	51.7	74.0	79.4	90.2	11.3	6.2	0.0	19.8	98.6	40.0	
		5.6	4.04	73.4	296	629	557	10.1	9.9	5.4	44.0	51.3	42.8	61.1	80.8	91.4	10.8	6.9	0.0	20.7	83.5	46.8	
		6.3	3.09	56.1	287	601	535	6.8	6.7	3.9	34.2	39.6	33.1	46.9	81.2	91.2	10.6	7.1	0.0	21.0	64.9	48.9	
FLORIDA EAST COAST BURNER-14" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, BURNER PORT-8" DIA., BOTTOM OPENINGS-25T-29T RINGS, SIDE OPENINGS-40 2" I.D. FLUES RIGHT AND LEFT.	B6-T12AB	12.3	6.29	114.5	320	677	612	18.1	17.9	9.2	66.7	78.6	65.3	93.9	79.6	91.7	12.2	4.8	0.0	18.3	115.1	28.2	
		10.2	5.66	102.9	310	666	596	15.8	15.6	7.7	60.2	70.5	58.9	84.2	79.4	90.8	11.2	6.1	0.0	19.8	112.4	38.9	
		8.0	5.00	91.0	303	653	584	13.5	13.3	7.0	53.6	62.8	52.4	74.9	79.9	91.2	11.3	6.0	0.0	19.7	96.0	38.1	
		6.8	4.54	82.5	298	639	570	12.4	12.2	6.9	49.1	57.2	47.9	68.0	80.0	90.9	10.9	6.6	0.0	20.4	92.8	43.7	
		5.4	4.09	74.4	292	632	562	10.2	10.1	5.6	44.4	51.7	43.2	61.6	80.3	91.0	10.4	7.1	0.0	21.3	87.0	48.7	
		3.2	3.12	56.7	286	597	533	6.3	6.3	3.5	34.4	39.7	33.3	46.7	80.0	90.3	9.8	8.1	0.0	22.6	70.6	60.0	
FLORIDA EAST COAST BURNER-14" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN, BURNER PORT-8" DIA., BOTTOM OPENINGS-35T-29T RINGS, SIDE OPENINGS-40 2" I.D. FLUES RIGHT AND LEFT.	B6-T13-AB	12.4	6.35	115.3	317	686	620	17.7	17.5	7.6	67.4	78.8	66.0	94.5	79.5	91.4	11.4	5.8	0.0	19.5	123.8	36.4	
		8.1	5.09	92.5	304	662	585	13.5	13.4	6.2	53.9	62.9	52.6	75.5	79.1	90.2	10.4	7.1	0.0	21.3	108.4	48.7	
		5.5	4.14	75.2	296	641	566	10.0	9.9	4.9	45.0	52.2	43.8	62.4	80.5	91.2	10.3	7.5	0.0	21.6	89.4	53.2	
		3.2	3.12	56.6	287	612	536	6.5	6.4	3.5	34.6	39.7	33.5	47.0	80.6	90.8	10.0	7.8	0.0	22.2	69.2	56.5	
CHAMBER TYPE TUBULAR BURNER-14" ABOVE BRICK 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN BURNER PORT-8" DIA., BOTTOM OPENINGS-25T 29T RINGS, SIDE OPENINGS-40 2" I.D. FLUES RIGHT AND LEFT.	B7-T12AB	12.6	6.27	114.1	318	670	610	17.6	17.4	8.5	66.7	78.5	65.3	93.5	79.5	91.4	11.4	5.7	0.0	19.5	122.1	35.4	
		10.2	5.75	104.7	309	666	605	15.6	15.4	7.5	60.7	71.3	59.4	85.2	79.0	90.4	11.4	5.9	0.0	19.5	112.4	37.2	
		8.1	5.00	91.0	306	647	582	13.0	12.8	6.5	52.9	61.7	51.7	73.5	78.3	89.2	10.6	7.0	0.0	21.0	104.9	47.8	
		6.8	4.63	84.2	299	641	575	11.5	11.4	5.7	49.5	57.7	48.3	68.7	79.1	90.0	10.7	6.8	0.0	20.8	96.1	45.6	
		5.4	4.03	73.3	295	630	566	9.6	9.4	4.7	43.4	50.3	42.2	59.8	79.1	89.6	10.3	7.5	0.0	21.6	87.1	53.2	
		3.2	3.16	57.5	287	613	548	6.2	6.1	3.1	34.6	39.6	33.5	47.2	79.6	89.4	9.9	7.9	0.0	22.4	70.7	57.7	
CHAMBER TYPE TUBULAR BURNER-14" ABOVE BRICK 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIREPAN BURNER PORT 8" DIA., BOTTOM OPENINGS-35T-29T RINGS, SIDE OPENINGS 40 2" I.D. FLUES RIGHT AND LEFT.	B7-T13AB	12.3	6.22	113.1	321	681	606	17.3	17.1	8.2	65.9	77.5	64.6	92.6	79.5	91.5	11.5	5.7	0.0	19.4	120.3	35.5	
		8.0	4.97	90.4	304	665	581	13.3	13.1	6.4	53.2	62.2	51.9	74.2	79.6	91.0	10.7	6.9	0.0	20.8	103.4	46.8	
		5.4	4.03	73.2	294	649	562	9.7	9.5	4.8	44.0	50.5	42.8	60.6	80.3	90.9	10.1	7.6	0.0	21.9	88.4	54.2	
MULTIPLE DIAMOND CHANNEL BURNER-8" ABOVE BRICK, 1" CROSS SPLIT ON 9 1/2" NOZZLE, T.&N.O. FIRE- PAN, T.&N.O. BURNER PORT, BOTTOM OPENINGS-25T- 29T RINGS, SIDE OPENINGS-40 2" I.D. FLUES RIGHT AND LEFT, T.&N.O. BAFFLER DOOR.	B8-T17-AB	12.2	6.43	116.9	319	684	616	16.6	16.3	6.9	66.4	78.5	65.0	94.0	78.0	89.9	11.9	5.2 (EST)	—	18.8	120.8	31.3	
		8.1	5.24	95.3	304	657	588	13.0	12.8	5.9	54.4	64.3	53.2	76.7	78.1	89.4	9.9	8.1 (EST)	—	22.6	118.3	60.2	
		5.4	4.15	75.5	293	635	564	9.2	9.0	4.2	44.2	51.3	43.0	61.2	78.7	89.1	10.2	7.6 (EST)	—	21.9	90.8	54.2	
		3.2	3.14	57.1	286	607	535	5.9	5.8	2.8	33.8	38.9	32.7	46.1	78.4	88.3	9.8	8.2 (EST)	—	22.8	71.5	61.4	

SUMMARY OF DATA																							
TEST ARRANGEMENT	TEST DESIG- NATION	EXHAUST NOZZLE PRESSURE P.S.I.G.	FIRING RATE		TEMPERATURES DEGREES FAHRENHEIT			DRAFTS INCHES, WATER			WATER RATES 1000 LBS PER HOUR		STEAM RATES 1000 LBS PER HOUR		BOILER EFFICIENCIES-%		FLUE GAS COMPOSITION-%			AIR FLOW FROM FLUE GAS ANALYSIS			
			1000 LBS PER HOUR	B.T.U. PER HOUR IN MILLIONS	EXHAUST STEAM	SUPER- HEATED STEAM	FLUE GAS	INSIDE ARRESTER	BEHIND ARRESTER	FIREBOX	WATER FROM TENDER	WATER TO BOILER	STEAM TO NOZZLE	EQUIV. EVAP. FROM AND AT 212°	EXCLUDING FEED WATER HEATER	INCLUDING FEED WATER HEATER	CARBON DIOXIDE	OXYGEN	CARBON MONOXIDE	LBS. AIR PER LB. OF OIL	LBS AIR PER HOUR IN THOUSANDS	PERCENT EXCESS AIR	
K. O. ALEXANDER ROTARY CUP BURNER-13" ABOVE BRICK, 3/4" CROSS SPLIT ON 9 1/2" NOZZLE, T. & N. O. FIREPAN, BURNER PORT-8" DIA., BOTTOM OPENINGS-24" X 12" AND 18" X 19", SIDE OPENINGS- NONE, BURNER WALL OPENING-12 1/2" X 6 1/2"	B9-T15AD	8.7	6.13	111.6	304	665	604	17.7	17.5	10.7	65.8	77.4	64.4	92.7	80.6	92.2	13.8	3.0	0.1	16.3	100.2	16.0	
		6.7	5.33	96.9	297	654	589	14.5	14.4	8.9	57.0	67.8	56.4	81.3	81.4	92.6	13.3	3.8	0.0	17.0	90.5	21.1	
		4.2	4.25	77.3	291	629	564	9.4	9.3	5.8	46.6	54.4	45.4	64.9	81.5	92.3	12.7	4.5	0.0	17.7	75.3	26.0	
		2.2	3.17	57.6	280	595	537	6.7	6.7	4.9	35.5	41.2	34.4	48.7	82.1	92.6	14.1	2.9	0.0	16.1	50.9	15.3	
K. O. ALEXANDER ROTARY CUP BURNER-13" ABOVE BRICK, 5/8" CROSS SPLIT ON 9 1/2" NOZZLE, T. & N. O. FIREPAN BURNER PORT-8" DIA., BOTTOM OPENINGS-24" X 12" AND 18" X 19", SIDE OPENINGS- NONE, BURNER WALL OPENING-12 1/2" X 6 1/2"	B9-T15AE	7.7	6.11	111.1	301	652	590	16.4	16.2	10.1	66.3	77.8	64.9	92.8	81.1	92.6	14.5	2.0	0.1	15.5	94.6	9.8	
		6.2	5.48	99.6	298	645	586	13.0	12.9	7.6	59.8	70.3	58.5	83.9	81.7	93.0	14.2	2.5	0.0	15.9	87.2	12.9	
		3.7	4.33	78.8	286	618	559	8.0	8.0	4.7	47.5	55.4	46.3	65.9	81.2	91.9	13.2	3.7	0.0	17.0	73.7	20.4	
		2.1	3.33	60.6	280	589	532	4.9	4.9	2.8	36.8	42.8	35.7	50.4	80.7	91.1	13.4	3.7	0.0	16.9	56.2	20.4	
NAGEL BURNERS-3, 7/8" CROSS SPLIT ON 9 1/2" NOZZLE, NAGEL FIREPAN, BOTTOM OPENING-1" X 7 1/2", SIDE OPENING-NONE, 1/8" PRIMARY AIR SLOTS IN BURNER CASTING WITH 1 1/2" ANNULAR OPENING AROUND CASTING.	B10-T18AC	10.9	6.52	118.6	310	693	615	16.5	16.3	8.1	67.9	80.6	66.5	97.1	79.5	91.3	12.4	4.6	0.0	18.0	117.6	26.7	
		10.8	6.45	117.4	315	695	625	15.8	15.5	7.6	66.4	78.9	65.0	95.1	78.6	90.4	12.0	5.1	0.0	18.6	120.0	30.5	
		7.4	5.27	95.8	302	674	599	12.2	12.0	6.1	55.2	65.3	54.0	78.7	79.7	90.8	11.8	5.5	0.0	19.0	99.8	33.8	
		4.8	4.43	80.6	291	652	580	8.6	8.5	4.4	47.5	55.6	46.3	66.8	80.5	91.2	11.8	5.5	0.0	19.0	84.0	33.8	
		2.4	3.01	54.7	283	603	534	4.6	4.5	2.5	33.3	38.5	32.2	45.5	80.7	91.1	11.2	6.5	0.0	20.0	60.2	42.9	
		2.3	3.04	53.4	283	605	543	4.5	4.4	2.3	33.4	38.8	32.3	46.0	80.6	90.9	11.0	6.0	0.0	20.0	61.0	37.9	
GYROJET N°323 BURNER-15" ABOVE BRICK, 7/8" CROSS SPLIT ON 9 1/2" NOZZLE, TAPER TYPE FIREPAN, BURNER PORT 8" DIA. WITH 6" THROAT, BOTTOM OPENING-20" X 17", SIDE OPENING- NONE, BURNER WALL OPENING-18" X 6"	B11-T18-AC	10.8	6.13	111.5	312	650	595	21.6	21.4	15.0	67.0	79.3	65.6	93.9	81.7	93.8	14.3	2.2 (EST)	—	15.8	96.9	11.4	
		7.7	5.07	92.2	301	633	571	16.4	16.2	11.6	55.9	65.8	54.6	77.9	81.9	93.5	13.7	3.1 (EST)	—	16.5	83.4	16.5	
		5.1	4.13	75.2	294	598	544	12.8	12.6	9.6	46.6	54.3	45.4	63.7	82.3	93.3	13.9	2.8 (EST)	—	16.3	67.2	14.7	
		2.3	2.78	50.6	283	561	503	6.7	6.6	5.3	32.5	37.1	31.4	43.2	82.9	93.0	13.7	3.1 (EST)	—	16.5	45.9	16.5	
GYROJET N°366 BURNER-15" ABOVE BRICK, 3/4" CROSS SPLIT ON 9 1/2" NOZZLE, TAPER TYPE FIREPAN, BURNER PORT-8" DIA. WITH 6" THROAT, BOTTOM OPENING-20" X 17", SIDE OPENING- NONE, BURNER WALL OPENING-18" X 6"	B12-T19AD	8.8	5.91	107.6	306	641	578	19.0	18.9	12.9	64.7	76.5	63.3	90.5	81.6	93.5	13.7	3.1 (EST)	—	16.5	97.5	16.5	
		6.5	5.08	92.5	297	628	572	16.5	16.3	11.6	56.7	66.9	55.4	79.1	83.0	94.5	13.1	3.7 (EST)	—	17.2	87.2	20.4	
		4.3	4.14	75.3	288	598	545	12.1	12.0	9.3	47.3	55.2	46.1	64.8	83.5	94.4	14.1	2.5 (EST)	—	16.0	66.3	12.9	
		2.2	2.91	53.0	284	567	512	6.8	6.8	5.5	34.1	39.0	33.1	45.6	83.5	93.6	14.0	2.6 (EST)	—	16.1	47.0	13.5	
GYROJET N°366-A BURNER-15" ABOVE BRICK, 7/8" CROSS SPLIT ON 9 1/2" NOZZLE, TAPER TYPE FIREPAN, BURNER PORT-8" DIA., BOTTOM OPENING-20" X 17", SIDE OPENING-NONE, BURNER WALL OPENING-18" X 6"	B13-T20-AC	10.7	6.28	113.9	314	652	603	19.3	19.1	12.2	68.3	80.4	66.9	95.4	81.2	93.2	13.9	2.8 (EST)	—	16.3	102.2	14.7	
		7.7	5.27	95.7	301	637	580	16.1	16.0	10.9	58.5	69.0	57.1	81.7	82.9	94.7	13.3	3.5 (EST)	—	16.9	89.3	19.0	
		5.1	4.35	78.9	294	618	559	12.9	12.8	9.4	48.8	57.4	47.6	67.6	83.0	94.2	13.1	3.7 (EST)	—	17.2	74.7	20.4	
		2.3	2.98	54.0	281	573	518	6.7	6.7	5.1	34.2	39.1	33.1	45.9	82.5	92.4	13.0	3.9 (EST)	—	17.3	51.5	21.7	